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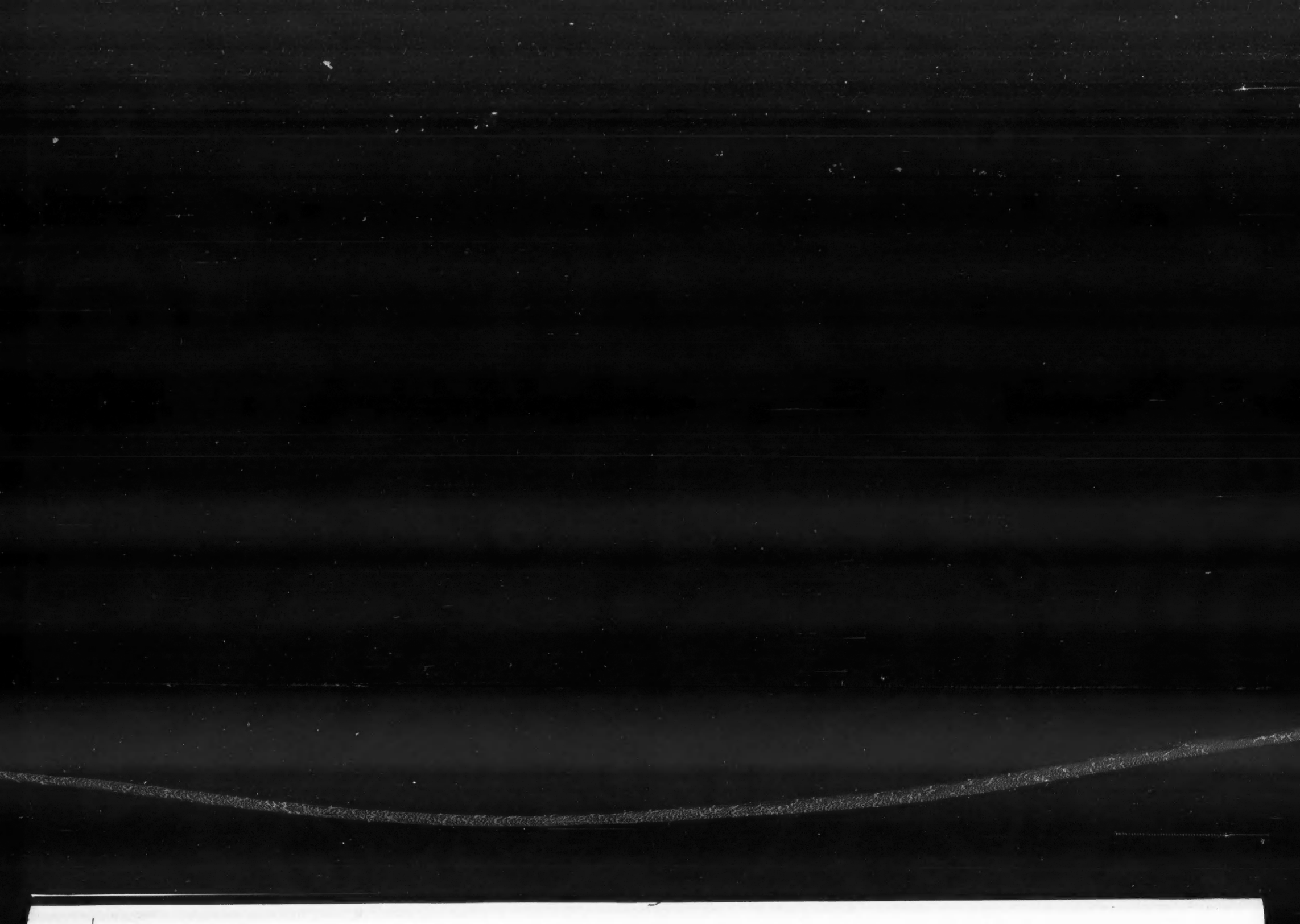


# THE MECHANICS OF LOCKED-COIL WIRE ROPES.

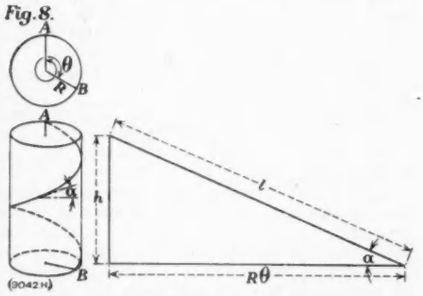
By PROFESSOR J. A. L. MATHESON.

(*Concluded from page* 581.)

THE treatment of the free open-coiled helical spring is well known, and it is only necessary here to quote the results. Some of the symbols used are explained in Fig. 8, herewith. E and G are the moduli of elasticity and rigidity, respectively, of the material of the wire; I and J are the second moments of area of the cross-section of the wire, I about a diameter and J the polar moment; A is the cross-sectional area of the wire. The change in vertical height of the spring, $\delta h$, is positive when the spring extends, and the angle of rotation, $\delta\theta$, is positive when the number of coils tends to increase. When an axial tensile load P is applied to the spring, R being the pitch radius of the helix and $l$ the length of the helical wire, the vertical extension, $\delta h_P$,

$$= P l \left( \frac{R^2 \sin^2\alpha}{E I} + \frac{R^2 \cos^2\alpha}{G J} + \frac{\sin^2\alpha}{A E} + \frac{\cos^2\alpha}{A G} \right),$$

*Fig. 8.*




assuming the shearing stress produced by the shearing component of the load to be uniformly distributed over the cross-section of the wire.

The axial rotation, $\delta\theta_P$, in such a direction as to increase the number of coils

$$= P R l \sin\alpha \cos\alpha \left( \frac{1}{G J} - \frac{1}{E I} \right).$$

When only an axial torque L is applied to the spring, in such a direction as to increase the number of coils, the vertical extension, $\delta h_L$ and the axial twist, $\delta\theta_L$, are given by:

$$\delta h_L = L l R \sin\alpha \cos\alpha \left( \frac{1}{G J} - \frac{1}{E I} \right)$$

$$\delta\theta_L = L l \left( \frac{\cos^2\alpha}{E I} + \frac{\sin^2\alpha}{G J} \right).$$

It will be noticed that the direct and shearing stress terms enter into the expression only for the vertical extension under axial load.

In the course of the analysis leading to the above results, it is found that the bending moment, twisting couple, direct force, and shearing force are the same at all sections of the wire, and the diminution in the diameter of the spring is the same throughout. If, at all points of the spring, the diameter is now brought back to its original value, the effect at all sections, except perhaps close to the ends, must be the same.

This statement would be the more justified if it could be shown that the relation between extension (and rotation) and distance from the support is a linear one. To test this, experiments were conducted in which the extension and rotation were measured at about the mid-point and quarter-points of the rope as well as at the ends. The arrangements for doing this are shown in Fig. 9, on this page. The experimental results of one such test are shown in Table I.

TABLE I.

| Station. | Distance from Support, Per cent. | Rotation, Per cent. | Extension, Per cent. |
|---|---|---|---|
| 0 | 100 | 100 | 100 |
| 1 | 70·1 | 70·0 | 69·5 |
| 2 | 47·9 | 48·5 | 46·6 |
| 3 | 24·7 | 25·2 | 25·5 |

The measurements required in these tests were rather difficult to make, and, in view of the probable error, the results quoted are considered to confirm the linearity of the relationship. The assumption is made, therefore, that, throughout the helical wire, the bending moment, M, and the twisting couple, T, are constant when the wire is constrained to maintain a constant helix diameter. The effect of the direct stress and vertical shearing stress will probably not be affected, although no proof of this has been found.

Now

$\frac{M}{EI}$ = change in curvature = $\delta\kappa$, say;

and the curvature

$$\kappa = \frac{\cos^2\alpha}{R} \text{ for a helix.}$$

Therefore,

$$\delta\kappa = \frac{-2 \sin\alpha \cos\alpha \, \delta\alpha}{R} = \frac{-\delta\alpha \sin 2\alpha}{R}$$

$$M = \frac{-\delta\alpha \sin 2\alpha \, E I}{R}.$$

Also,

$\frac{T}{GJ}$ = change in tortuosity* = say, $\delta\tau$;

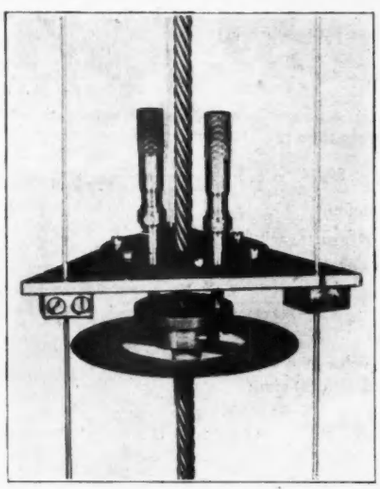


FIG. 9. SIMULTANEOUS TESTS OF EXTENSION AND ROTATION.

and

$$\tau = \frac{\sin\alpha \cos\alpha}{R} \text{ for a helix.}$$

Therefore,

$$\delta\tau = \frac{(\cos^2\alpha - \sin^2\alpha)}{R} = \frac{\delta\alpha \cos^2\alpha}{R},$$

and

$$T = \frac{\delta\alpha \cos 2\alpha \, G J}{R}.$$

Let P be that part of the load applied to the rope which acts on a particular helical wire. Then, if the vertical extension be $\delta h$, the total strain energy stored in the wire will be $\frac{1}{2} P \delta h$, of which $\frac{1}{2} P \delta h'$ is accounted for by bending and twisting, and $\frac{1}{2} P \delta h''$ by direct and shearing stress; and $\delta h = \delta h' + \delta h''$.

Dealing first with the bending and twisting terms,

$$\tfrac{1}{2} P \delta h' = \int_0^l \frac{M^2 \, dl}{2 EI} + \int_0^l \frac{T^2 \, dl}{2 GJ}$$

$$= l \left( \frac{M^2}{2 EI} + \frac{T^2}{2 GJ} \right)$$

$$= \frac{l \, \delta\alpha^2}{2 R^2} (EI \sin^2 2\alpha + GJ \cos^2 2\alpha).$$

Also

$$h = l \sin\alpha;$$

that is,

$$\delta h' = l \cos\alpha \, \delta\alpha$$

$$\delta h' = \frac{P l R^2 \cos^2\alpha}{E I \sin^2 2\alpha + G J \cos^2 2\alpha}.$$

* *Treatise on the Theory of Elasticity*, by A. E. H. Love, M.A. Vol. II, page 75. Cambridge University Press, 1893.

The direct and shearing stress terms give

$$\tfrac{1}{2} P \delta h'' = \int_0^l \frac{F^2 \, dl}{2 AE} + \int_0^l \frac{S^2 \, dl}{2 AG}$$

$$\delta h'' = P l \left( \frac{\sin^2\alpha}{A E} + \frac{\cos^2\alpha}{AG} \right)$$

$$\delta h_P = \delta h' + \delta h''$$

$$= P l \left\{ \frac{R^2 \cos^2\alpha}{E I \sin^2 2\alpha + G J \cos^2 2\alpha} + \frac{\sin^2\alpha}{A E} + \frac{\cos^2\alpha}{A G} \right\} \quad (1)$$

The amount of rotation can also be deduced, for $\theta$ being the total angle turned through by the radius vector of the helix (Fig. 8), $R\theta = l \cos\alpha$.

$$R \, \delta\theta = -l \sin\alpha \, \delta\alpha,$$

$$\delta\theta_P = -\frac{P l R \sin\alpha \cos\alpha}{E I \sin^2 2\alpha + G J \cos^2 2\alpha}. \quad . \quad (2)$$

The direct and shearing stress terms, as before, will not affect the amount of rotation. The sign of $\delta\theta_P$ shows that the spring now unwinds under an axial tensile load.

Considering next the effect of axial torque: as in a free spring, only the effect of bending and twisting need be considered, for a torque, L, applied to the spring, does not produce direct or shearing

*Fig. 10.*

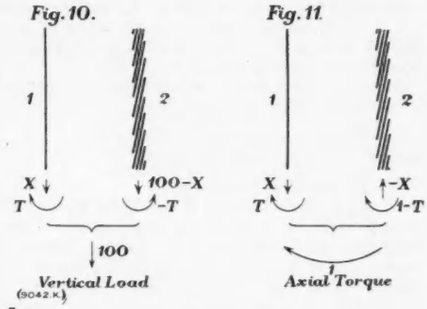



*Fig. 11.*




stress,

$$\tfrac{1}{2} L \delta\theta = \int_0^l \frac{M^2 \, dl}{2 EI} + \int_0^l \frac{T^2 \, dl}{2 GJ}$$

$$= l \left( \frac{M^2}{2 EI} + \frac{T^2}{2 GJ} \right)$$

$$= \frac{l \, \delta\alpha^2}{2R} (EI \sin^2 2\alpha + GJ \cos^2 2\alpha).$$

As before, $\delta\alpha = \frac{-R \, \delta\theta}{l \sin\alpha}$, and $\delta\alpha = \frac{\delta h}{l \cos\alpha}$; therefore

$$\delta\theta_L = \frac{L l \sin^2\alpha}{EI \sin^2 2\alpha + GJ \cos^2 2\alpha}. \quad . \quad . \quad (3)$$

and

$$\delta h_L = -\frac{L l R \sin\alpha \cos\alpha}{EI \sin^2 2\alpha + GJ \cos^2 2\alpha}. \quad . \quad (4)$$

It will be noticed that, in these calculations, the direction of the applied torque does not affect the numerical values of the resulting deformation, but only alters the sign. A large number of experiments showed that this rule does hold in ropes, at least to the same order of accuracy as the general theory. This means that, under a twisting torque, the rope shortens, and hence the core must be in compression.

The application to a simple rope is as follows. A concentric rope can be regarded as a statically-indeterminate structure, since the final partition of load between the layers depends on their relative elasticity. In the simplest case, that of a core wire surrounded by a single layer of helical wires, there are two redundant or statically-indeterminate quantities, as will be seen from Fig. 10, herewith. Consider first the case of the rope under a tensile load of 100 lb. The share of this taken by the core wire is the unknown amount X, and therefore 100 − X is taken by the helical wires. Equation (2) shows that, under this vertical load, the helical wires tend to untwist, but, since the core and helical wires are connected at their ends, the former is forced to twist a certain amount, and an unknown torque T is called into play. If the torque T, acting on the core, be regarded as the "action," then an equal and opposite "reaction" of − T acts on the helical wires. This, too, produces a change of length and rotation.

Two equations are required to determine these unknowns, and the fact that the core and helical

wires extend and rotate by the same amount enables these equations to be formulated.

The choice of the best sign convention presents some difficulty. Perhaps the most convenient is to make the tension and extension positive, and to make the torque rotation positive when it is in such a direction as to increase the number of coils of the helical wires (that is, to twist them). Even this requires care when applied to ropes with several layers, where one or more layers lie in the opposite direction to the others. With this convention, Fig. 10 illustrates the loading used in the following calculations. Initially, T and X are both taken positive in the core wire. It is convenient to base the calculations on the action of the rope under a load of 100 lb.

Let the prefix 1 refer to the core wire and the prefix 2 to the helical wires, and let the suffixes T, X, etc., denote the loading. Thus ${}_1\delta h_{P=X}$ denotes the extension of the core wire under load X and ${}_1\delta\theta_{L=T}$ denotes the angle of rotation of the core wire under a torque T. These are known from the elastic properties of the core wire. Similarly, ${}_2\delta h_{P=100-X}$, which denotes the extension of the helical wires, under a net load of 100 − X, and can be found from equation 1, above; and ${}_2\delta h_{L=-T}$, denoting the change of length of the helical wires under a torque − T, which can be found from equation 4, above.

Equating the extension of the core wire to that of the helical wires, we have

$$ {}_1\delta h_{P=X} = {}_2\delta h_{P=100-X} + {}_2\delta h_{L=-T} \qquad (5) $$

and by equating rotations,

$$ {}_1\delta\theta_{L=T} = {}_2\delta\theta_{P=100-X} + {}_2\delta\theta_{L=-T} \qquad (6) $$

From these two equations, T and X are found. It is then easy to calculate the deformation of the rope as a whole under a load of 100 lb., since it must equal that of the core wire under T and X. The extension and rotation of the two combined are designated ${}_A\delta h_{P=100}$ and ${}_A\delta\theta_{P=100}$, respectively.

A similar technique can be used to solve the problem of the rope under unit torque, (Fig. 11, page 601), and the following equations emerge :—

$$ {}_1\delta h_{P=X} = {}_2\delta h_{P=-X} + {}_2\delta h_{L=1-T}, \qquad (7) $$

$$ {}_2\delta\theta_{L=T} = {}_2\delta\theta_{P=-X} + {}_2\delta\theta_{L=1-T}. \qquad (8) $$

These enable the new values of T and X to be determined, and from them, the change of length and the rotation of the whole rope can be found as before. They are ${}_A\delta h_{L=1}$ and ${}_A\delta\theta_{L=1}$, respectively.

The method of applying the theory to a rope with several layers of helical wires is as follows. After the values of ${}_A\delta h$ and ${}_A\delta\theta$ under load and torque have been determined, they can be combined with the figures for the next helical layer, denoted by the prefix 3, in the following way. The figures for ${}_3\delta h_P$, ${}_3\delta\theta_P$, ${}_3\delta h_L$ and ${}_3\delta\theta_L$ are computed from equations (1) to (4). Under a load of 100 lb., the extensions equal

$$ {}_A\delta h_{P=X} + {}_A\delta h_{L=-T} = {}_3\delta h_{P=100-X} + {}_3\delta h_{L=-T} \qquad (9) $$

and the rotations equal

$$ {}_A\delta\theta_{P=X} + {}_A\delta\theta_{L=-T} = {}_3\delta\theta_{P=100-X} + {}_3\delta\theta_{L=-T} \qquad (10) $$

From the values of T and X obtained from these equations, we can obtain ${}_B\delta h_{P=100}$ and ${}_B\delta\theta_{P=100}$, where the prefix B refers to all three layers acting simultaneously.

Under a torque of 1 lb. in., the extensions are

$$ {}_A\delta h_{P=X} + {}_A\delta h_{L=-T} = {}_3\delta h_{P=-X} + {}_3\delta h_{L=1-T}. \qquad (11) $$

and the rotations are

$$ {}_A\delta\theta_{P=X} + {}_A\delta\theta_{L=-T} = {}_3\delta\theta_{P=-X} + {}_3\delta\theta_{L=1-T}. \qquad (12) $$

These lead to the values of ${}_B\delta h_{L=1}$ and ${}_B\delta\theta_{L=1}$.

The effect of a further layer (prefix 4) can be obtained similarly by combining the appropriate values of ${}_B\delta h$ and ${}_B\delta\theta$ with those of ${}_4\delta h$ and ${}_4\delta\theta$, in exactly the same way as the above. An example of the work for a 19-wire rope is given below.

*Calculations for Rope* 5 (*19 Wires*).—This rope consisted of 12 wires, 0·104 in. in diameter (layer 3), over six wires, 0·104 in. in diameter (layer 2), over one core wire, 0·122 in. in diameter (layer 1). Because of the compression imposed during stranding, the final diameter of the rope is about 1½ per cent. less than the value computed from the wire sizes. The following figures are calculated from measurements of the rope as manufactured. Layer 3, with a pitch-circle diameter of 0·43 in., had a lay of 6·075 in., the value of the angle $\alpha$ being 77 deg. 28 min. The corresponding values for layer 2 were 0·224 in., 3·22 in., and 77 deg. 40 min. The values of the elastic properties of the wires, obtained from experiments, are shown in Table II. The

TABLE II.—*Elastic Properties of Wires.*

| Wire from Layer. | E I. | G J. | A E. | A G. |
|---|---|---|---|---|
| 3 | 168·1 | 134·8 | 247,000 | 99,000 |
| 2 | 167·5 | 134·0 | 240,000 | 96,000 |
| 1 | | 246·0 | 340,000 | |

experiments were conducted on ropes about 16 ft. long, but for convenience the results have been reduced to a standard length of 100 in.

For the core wire and layer 2,

R = 0·112 in., and $h$ = 100 in., therefore $l$ = 102·4 ; $\alpha$ = 77 deg. 40 min., $\sin\alpha$ = 0·9769, $\sin 2\alpha$ = 0·4173, $\cos\alpha$ = 0·2136, and $\cos 2\alpha$ = −0·9087.

Suppose that, of the total load acting on the rope, 1 lb. acts on layer 2, that is, 0·167 lb. per wire. Then, by equation (1),

$$ \delta h_P = Pl\left\{\frac{R^2\cos^2\alpha}{E\,I\sin^2 2\alpha + G\,J\cos^2 2\alpha} + \frac{\sin^2\alpha}{A\,E} + \frac{\cos^2\alpha}{A\,G}\right\}; $$

$$ {}_2\delta h_{P=1} = 0{\cdot}000146 \text{ in.} $$

By equation (2),

$$ \delta\theta_P = -\frac{P\,l\,R\sin\alpha\cos\alpha}{E\,I\sin^2 2\alpha + G\,J\cos^2 2\alpha}; $$

therefore

$$ {}_2\delta\theta_{P=1} = -0{\cdot}00286 \text{ radian.} $$

By equation (3),

$$ \delta\theta_L = \frac{L\,l\sin^2\alpha}{E\,I\sin^2 2\alpha + G\,J\cos^2 2\alpha}, $$

and

$$ {}_2\delta\theta_{L=1} = 0{\cdot}117 \text{ radian.} $$

Equation (4) gives

$$ \delta h_L = -\frac{L\,I\,R\sin\alpha\cos\alpha}{E\,I\sin^2 2\alpha + G\,J\cos^2 2\alpha}, $$

therefore

$$ {}_2\delta h_{L=1} = -0{\cdot}00286 \text{ in.} $$

It will be noticed that $\delta\theta_{P=1} = \delta h_{L=1}$; this follows at once from the Reciprocal Theorem. The appropriate elongation and twist of the core wire, respectively,

$$ {}_1\delta h_{P=1} = \frac{P\,h}{A\,E} = 0{\cdot}000294 \text{ in.}; $$

and

$$ {}_1\delta\theta_{L=1} = \frac{L\,h}{G\,J} = 0{\cdot}406 \text{ radian.} $$

For a load of 100 lb., by equation (5),

$$ {}_1\delta h_{P=X} = {}_2\delta h_{P=100-X} + {}_2\delta h_{L=-T}; $$

that is,

$$ 0{\cdot}000294\,X = 0{\cdot}000146\,(100 - X) + 0{\cdot}00286\,T. $$

By equation (6),

$$ {}_1\delta\theta_{L=T} = {}_2\delta\theta_{P=100-X} + {}_2\delta\theta_{L=-T} $$

$$ 0{\cdot}406\,T = -0{\cdot}00286\,(100 - X) - 0{\cdot}117\,T; $$

hence

$$ T = -0{\cdot}379 \text{ lb.-in.}, $$

and

$$ X = 30{\cdot}7 \text{ lb.} $$

Therefore

$$ {}_A\delta h_{P=100} = {}_1\delta h_{P=X} = 0{\cdot}000294 \times 30{\cdot}7 = 0{\cdot}00903 \text{ in. } (0{\cdot}00905 \text{ in.})^* $$

$$ {}_A\delta\theta_{P=100} = {}_1\delta\theta_{L=T} = -0{\cdot}406 \times 0{\cdot}379 = -0{\cdot}154 \text{ radian } (-0{\cdot}155). $$

For a torque of 1 lb.-in., by equation (7),

$$ {}_1\delta h_{P=X} = {}_2\delta h_{P=-X} + {}_2\delta h_{L=1-T}; $$

that is, $0{\cdot}000294\,X = -0{\cdot}000146\,X - 0{\cdot}00286\,(1 - T)$. By equation (8),

$$ {}_1\delta\theta_{L=T} = {}_2\delta\theta_{P=-X} + {}_2\delta\theta_{L=1-T}, $$

and

$$ 0{\cdot}406\,T = 0{\cdot}00286\,X + 0{\cdot}117\,(1 - T) $$

hence

$$ T = 0{\cdot}196 \text{ lb.-in.} $$

and

$$ X = -5{\cdot}23 \text{ lb.}, $$

therefore

$$ {}_A\delta h_{L=1} = {}_1\delta h_{P=X} = -0{\cdot}00154 \text{ in. } (-0{\cdot}00155) $$

$$ {}_A\delta\theta_{L=1} = {}_1\delta\theta_{L=T} = 0{\cdot}0795 \text{ radian } (0{\cdot}0791). $$

For the outer layer (prefix 3), R = 0·215 in., $h$ = 100 in., $l$ = 102·4 in., and $\alpha$ = 77 deg. 28 min.

Equation (1) gives ${}_3\delta h_{P=1} = 0{\cdot}000169$ in.

Equation (2) gives ${}_3\delta\theta_{P=1} = -0{\cdot}00276\,r$.

Equation (3) gives ${}_3\delta\theta_{L=1} = 0{\cdot}0577r$.

Equation (4) gives ${}_3\delta h_{L=1} = -0{\cdot}00276$ in.

*Calculations for Rope* 6.—The following calculations are given in brief to illustrate the treatment of a rope with layers of helical wires of different hands. The construction was as follows :—

12 wires, 0·112 in. in diameter left-hand.
Over six wires, 0·123 in. in diameter, right-hand } A
Over one wire, 0·148 in. in diameter } B

Core wire and layer 2 (A section) : from equations (1) to (4) :—${}_2\delta\theta_{P=1} = 0{\cdot}000261$ in. ; ${}_2\delta\theta_{P=1} = -0{\cdot}00338$ radian ; ${}_2\delta\theta_{L=1} = 0{\cdot}0591$ radian; and ${}_2\delta h_{L=1} = -0{\cdot}00338$ in.

Also, for the core wire, ${}_1\delta h_{P=1} = 0{\cdot}000213$ in., and ${}_1\delta\theta_{L=1} = 0{\cdot}1823$ radian.

Combining these results, by means of equations (5) to (8), ${}_A\delta h_{P=100} = 0{\cdot}01067$ in. ; ${}_A\delta\theta_{P=100} = -0{\cdot}127$ radian ; ${}_A\delta h_{L=1} = -0{\cdot}00127$ in. ; ${}_A\delta\theta_{L=1} = 0{\cdot}0295$ radian.

Layer 3 and B-section. The signs of the above give the direction of the movement of the A section in relation to the hand of layer 2. In combining these results with the following, the signs of ${}_A\delta\theta_{P=100}$ and ${}_A\delta h_{L=1}$ must be changed to positive, to conform to the hand of layer 3 : ${}_3\delta h_{P=1} = 0{\cdot}000643$ in. ; ${}_3\delta\theta_{P=1} = -0{\cdot}00477$ radian ; ${}_3\delta\theta_{L=1} = 0{\cdot}0381$ radian ; and ${}_3\delta h_{L=1} = -0{\cdot}00477$ in.

From equations (9) to (12) : ${}_B\delta h_{P=100} = 0{\cdot}00305$ in. ; ${}_B\delta\theta_{P=100} = -0{\cdot}0133$ radian ; ${}_B\delta h_{L=1} = -0{\cdot}000133$ in. ; and ${}_B\delta\theta_{L=1} = 0{\cdot}00255$ radian.

These signs are now in conformity with the hand of layer 3, that is, left-hand.

For a load of 100 lb., by equation (9),

$$ {}_A\delta h_{P=X} + {}_A\delta h_{L=-T} = {}_3\delta h_{P=100-X} + {}_3\delta h_{L=-T} $$

$$ 0{\cdot}0000903\,X - 0{\cdot}00154\,T = 0{\cdot}000169\,(100 - X) + 0{\cdot}00276\,T. $$

By equation (10) :

$$ {}_A\delta\theta_{P=X} + {}_A\delta\theta_{L=-T} = {}_3\delta\theta_{P=100-X} + {}_3\delta\theta_{L=-T} $$

$$ -0{\cdot}00154\,X + 0{\cdot}0795\,T = -0{\cdot}00276\,(100 - X) - 0{\cdot}0577\,T, $$

therefore

$$ T = 0{\cdot}0651 \text{ lb.-in.} $$

and

$$ X = 66{\cdot}25 \text{ lb.} $$

$$ {}_B\delta h_{P=100} = {}_A\delta h_{P=X} + {}_A\delta h_{L=-T} = 0{\cdot}0059 \text{ in. } (0{\cdot}0062). $$

$$ {}_B\delta\theta_{P=100} = {}_A\delta\theta_{P=X} + {}_A\delta\theta_{L=-T} = -0{\cdot}0968 \text{ radian } (-0{\cdot}0925). $$

For a torque of 1 lb.-in., by equation (11) :

$$ {}_A\delta h_{P=X} + {}_A\delta h_{L=-T} = {}_3\delta h_{P=-X} + {}_3\delta h_{L=1-T} $$

$$ 0{\cdot}0000903\,X - 0{\cdot}00154\,T = -0{\cdot}000169\,X - 0{\cdot}00276(1 - T). $$

By equation (12) :

$$ {}_A\delta\theta_{P=X} + {}_A\delta\theta_{L=-T} = {}_3\delta\theta_{P=-X} + {}_3\delta\theta_{L=1-T} $$

$$ -0{\cdot}00154\,X + 0{\cdot}0795\,T = 0{\cdot}00276\,X + 0{\cdot}0577\,(1 - T), $$

therefore

$$ T = 0{\cdot}1815 \text{ lb.-in.} $$

and

$$ X = -7{\cdot}657 \text{ lb.} $$

$$ {}_B\delta h_{L=1} = {}_A\delta h_{P=X} + {}_A\delta h_{L=-T} = -0{\cdot}00097 \text{ in. } (-0{\cdot}000825). $$

$$ {}_B\delta\theta_{L=1} = {}_A\delta\theta_{P=X} + {}_A\delta\theta_{L=-T} = 0{\cdot}0262 \text{ radian } (0{\cdot}0264). $$

As in the former example, the figures given in brackets represent the corresponding experimental results.

Tables III and IV, opposite, give the results of the experiments and the corresponding calculated estimates. Table III gives the results in detail, reduced to a standard length of 100 in. Table IV gives an analysis of the figures for ropes 3, 4, 5, 6,

* The figures given in brackets are the experimental results.

# THE MECHANICS OF LOCKED-COIL WIRE ROPES.

TABLE III.—COMPARISON OF EXPERIMENTAL AND CALCULATED FIGURES.

| Rope. | Construction. | Extension Due to 100-lb. Load, In. × 10-4 | | Rotation Due to 100-lb. Load, Deg. | | Twist Due to 1 lb.-in. Torque, Deg. | | Shortening Due to 1 lb.-in. Torque, In. × 10-4 | | Untwist Due to 1 lb.-in. Torque, Deg. | | Extension Due to 1 lb.-in. Torque, In. × 10-4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Expt. | Calcd. | Expt. | Calcd. | Expt. | Calcd. | Expt. | Calcd. | Expt. | Calcd. | Expt. | Calcd. |
| 3 | 6 wires 0·111 in. diameter<br>Over 1 „ 0·154 in. „ | 120 | 116 | −6·8 | −7·4 | 1·67 | 1·76 | 11·9 | 13·0 | 1·76 | 1·76 | 12·1 | 13·0 |
| 4 | 5 wires 0·084 in. diameter<br>Over 1 „ 0·065 in. „ | 163 | 165 | −20·2 | −20·9 | 16·89 | 16·79 | 38·5 | 36·6 | 16·89 | 16·79 | 38·7 | 36·6 |
| 5 | 12 wires 0·104 in. diameter R.H. } B<br>Over 6 „ 0·104 in. „ R.H. } A<br>„ 1 „ 0·122 in. „ | 62<br>90 | 59<br>90 | −5·3<br>−8·9 | −5·5<br>−8·8 | 1·51<br>4·55 | 1·50<br>4·56 | 8·2<br>15·5 | 9·7<br>15·4 | 1·54<br>4·53 | 1·50<br>4·56 | 9·7<br>15·4 | 9·7<br>15·4 |
| 6 | 12 wires 0·112 in. diameter L.H. } B<br>Over 6 „ 0·123 in. „ R.H. } A<br>„ 1 „ 0·148 in. „ | 38<br>119 | 31<br>107 | −0·6<br>−7·0 | −0·3<br>−7·3 | 0·16<br>1·61 | 0·15<br>1·69 | 1·3<br>11·8 | 1·3<br>12·7 | 0·14<br>1·61 | 0·15<br>1·69 | 1·2<br>12·9 | 1·3<br>12·7 |
| 9 | 12 wires 0·113 in. diameter L.H. } B<br>Over 6 „ 0·113 in. „ L.H. } A<br>„ 1 „ 0·140 in. „ | 102<br>141 | 87<br>121 | −4·9<br>−8·6 | −5·3<br>−8·8 | 0·86<br>2·17 | 0·76<br>2·13 | 8·5<br>14·1 | 9·3<br>15·4 | 1·08<br>2·22 | 0·76<br>2·13 | 8·5<br>15·3 | 9·3<br>15·4 |
| 10 | 12 wires 0·113 in. diameter L.H. } B<br>Over 6 „ 0·113 in. „ L.H. } A<br>„ 1 „ 0·140 in. „ | 99<br>137 | 88<br>123 | −4·6<br>−8·5 | −5·3<br>−8·7 | 0·92<br>2·08 | 0·75<br>2·12 | 8·5<br>13·4 | 9·2<br>15·3 | 0·97<br>2·17 | 0·75<br>2·12 | 8·1<br>14·1 | 9·2<br>15·3 |
| 11 | 11 wires 0·071 in. diameter L.H. } B<br>Over 6 „ 0·070 in. „ L.H. } A<br>„ 1 „ 0·085 in. „ | 222<br>299 | 210<br>283 | −17·8<br>−33·8 | −20·7<br>−35·1 | 7·6<br>16·1 | 5·0<br>15·5 | 32<br>57 | 36<br>61 | 8·5<br>16·4 | 5·0<br>15·5 | 32<br>59 | 66<br>13 |
| The calculations for the following ropes, in which the helical wires were rather loose on the cores, were made on the assumption that the helices were quite free to contract. | | | | | | | | | | | | | |
| 7 | 5 wires 0·080 in. diameter<br>Over 1 „ 0·078 in. „ | 563 | 566 | −1·22 | +3·02 | 18·9 | 22·0 | 11·7 | −5·3 | 20·9 | 22·0 | 3·1 | −5·3 |
| 8 | 5 wires 0·080 in. diameter<br>Over 1 „ 0·109 in. „ | 376 | 370 | +1·69 | +1·38 | | | | | | | | |

TABLE IV.—COMPARISON OF EXPERIMENTAL AND CALCULATED FIGURES.

| Experiment. | Discrepancy, Per cent. | | | | | |
|---|---|---|---|---|---|---|
| | A Sections. | | | B Sections. | | |
| | Max. | Min. | Average. | Max. | Min. | Average. |
| Extension due to 100-lb. load | −14·2 | +1·1 | −6·1 | −18·9 | −4·8 | −11·0 |
| Rotation due to 100-lb. load | + 9·0 | −1·1 | +3·5 | +21·0 | +4·8 | +12·3 |
| Twist due to 1 lb.-in. torque | + 5·2 | −3·8 | +0·8 | −34·3 | −0·6 | −15·2 |
| Shortening due to 1 lb.-in. torque | +14·1 | −5·0 | +5·0 | +17·6 | +1·5 | + 9·0 |
| Untwist due to 1 lb.-in. torque | + 5·0 | −5·5 | −1·0 | −41·2 | +5·0 | −17·5 |
| Extension due to 1 lb.-in. torque | + 8·5 | −5·5 | +1·8 | +13·6 | −0·5 | + 8·9 |

9 and 10 in this way: the discrepancies between experiment and theory are expressed as a percentage of the experimental figures, the maximum, minimum and average discrepancies being given. In Table IV, the results for the A sections—that is, the core wire and the first layer of helical wires combined—and the B sections, which include the next layer of helical wires, are given separately. It will be noticed at once that the latter results are not so satisfactory as the former. This is intrinsic in any treatment of a statically-indeterminate problem, since inaccuracies in the determination of one redundant quantity necessarily affect the others, often to an undue extent.

The importance of the tightness of the helical wires is clearly brought out, for the amount of extension under load is under-estimated, and the amount of rotation over-estimated. Both these results would follow if the helical wires were able to contract in pitch diameter. That this is likely to occur to a small extent is shown by the fact that in rope 6, for example, the outer helices would only contract by less than 0·001 in. under a load of 100 lb. if the core were entirely absent. There is some evidence that the discrepancies are systematic, suggesting that a longer series of experiments would enable working coefficients to be determined, at least for the products of one manufacturer.

On the whole, in view of the fact that the wires of the rope cannot be disposed exactly as assumed in the theory, the results can be regarded as satisfactory. Several effects have been necessarily ignored, particularly the initial self-straining, which must have some bearing on the partition of load, but which cannot be estimated at present.

The conclusions reached from the foregoing arguments are as follows. Ropes in which the helical wires are all laid in the same direction untwist under load; free helical springs tend to twist. The effect of a twisting torque is to shorten the rope, and of an untwisting torque to lengthen it; this also is the reverse of the behaviour of free springs. Locked-coil ropes function as statically-indeterminate structures, the partition of load between the individual layers of wires depending on their relative elasticity. Since the loads in the wires differ from layer to layer, the term "modulus of elasticity," with its implication of uniform stress should not be used in connection with wire ropes. The theory developed enables the deformation of a simple rope within the elastic range to be predicted with reasonable accuracy.

As mentioned above, the apparatus available was not adequate for tests on full-size ropes, but it was thought worth while to experiment on some small ropes having shaped wires as well as round wires. These ropes were really models, being much smaller in diameter than those normally used. They were necessarily made on standard rope-making machines, designed for normal sizes of ropes, and, as a result, they were by no means perfectly compacted.

Three ropes were used in the experiments, and these were selected to include the three main types of shaped wires commonly used. Rope 9 had an outer layer consisting of 20 wires, each the shape of the sector of an annulus and usually called a "wedge" wire. Rope 10 had an outer layer of ten $z$-shaped or "half-lock" wires, arranged alternately with ten round wires. Rope 11 was a locked-coil rope, $\frac{5}{8}$-in. in diameter, having 23 full-lock wires, 12 wedge wires, and an 18-wire core. The construction of the cores of the above ropes, and details of the results of the experiments on them are given in Table II, opposite.

In each case, the usual tests were carried out, namely, a loading test, a twisting test, an untwisting test, and a test to determine the torque required to prevent rotation under load. The outer covers were then stripped off, and similar tests conducted on the cores.

The outer wires of ropes 9 and 10 were somewhat loose on the cores, and it is not surprising, therefore, that the agreement between experiment and theory was poor; in fact, the actual extensions measured were about twice those given by the theory. No useful conclusions, therefore, can be drawn from these tests. In making the calculations for rope 10, where the outer layer consisted of alternate round and "rail" wires, the effects of these two types of wire were considered separately in the first instance. This method gave almost the same result as the simpler, though theoretically less justifiable, method of taking the average of the elastic constants for the two types of wire.

In the case of rope 11, a new problem arises, because the $z$-wires have no axis of symmetry and therefore do not bend in the same plane as the applied bending moment. It was considered that the interlocking of adjacent wires must prevent unsymmetrical bending, and the effective flexural rigidity was obtained by a cantilever bending test in which the sample wire was prevented from deflecting at right angles to the plane of the applied bending moment by a light cord. However, the results so obtained are hopelessly inaccurate, for the rope extended less than one-third of the amount indicated by the theory. This shows that the full-lock layer is much stiffer than was thought at first. The layer of wedge wires, in contrast, yielded results which agreed with the theory to the same order of accuracy as do the round wires.

Several possible theories to account for the unexpected stiffness of the full-lock layer have been examined, and quite a close approximation to the correct result has been obtained by a calculation based on the assumption that the only type of deformation which these wires are free to undergo is that due to direct tensile stress. In the absence of further evidence, however, this must still be regarded as conjectural.

From the results obtained in the experiments, it was possible to work backwards through a series of equations based on equations (9) to (12) to determine the share of the load taken by each layer. This shows that the outer layer takes 81·5 per cent. of the load, the wedge layer takes 1·3 per cent., the 11-wire layer, 2·6 per cent., the six-wire layer, 10·2 per cent., and the core wire, 4·4 per cent. In terms of the individual wires, each full-lock wire carries 3·54 lb. and the core wire 4·4 lb., when there is 100 lb. load on the rope. If this relationship is maintained at higher loads, the core wire and the

outer wires may be overstressed, even at normal working loads. In any event, these results indicate a state of affairs very different from the ideal condition in which all parts of the structure have the same factor of safety.

It is possible that the above considerations provide a clue to the solution of the problem of wavy ropes, for, if the outer wires are in fact stressed beyond the elastic limit under working conditions, they will become longer, and will presumably cease to fit together into the smooth layer normally associated with this type of rope. Unfortunately, the apparatus available was only suitable for testing ropes which were quite small in comparison with the heavy winding ropes now in use. It is hoped to continue the investigation with more substantial equipment.

In conclusion, the author wishes to acknowledge the support given to this research by the Whitecross Company, Limited, of Warrington, who financed it and provided the specimens, and, in particular, by the late Mr. H. D. Lloyd, at whose suggestion the work was undertaken; and his indebtedness to Professor C. Batho, D.Sc., M.I.C.E., for the facilities placed at his disposal in the civil engineering laboratories at Birmingham University, and to Mr. O. P. Hanson, B.Sc., who assisted in a great deal of the work.

## LITERATURE.

*Introduction to Aerodynamics of a Compressible Fluid.* By PROFESSOR H. W. LIEPMANN and A. E. PUCKETT. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 4 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 24*s.* net.]

THIS book will be welcomed by workers in the field of high-speed flow in aerodynamics and gas turbines, not only because of the almost complete dearth of books on the subject, but because of its intrinsic merits. During the present decade, the rate of development of the subject has increased enormously, for obvious reasons, but the major advances are scattered in articles in the world's scientific journals and in research reports of limited circulation; there is, therefore, an urgent need for a text-book setting out the present knowledge of fundamentals. This book goes far to meet that need. It is easy to read, and its arrangement and style are clear and logical; there is no detectable woolliness or looseness of argument—sins which would have been pardonable, in some measure, in view of the difficulty and the rapid rate of development of the subject. It must be emphasised that the book does not deal with the more practical problems of high-speed flight; these have been avoided, on the grounds that, at the time of writing, the technique of experiments was uncertain and most data were unreliable, while there was no uniform argument as to their interpretation. In any case, most of the data were not available for publication. It is hoped that the time will soon be ripe for a book dealing with these problems.

The first chapter deals with the basic thermodynamic concepts required, a valuable feature being the clear distinction drawn between adiabatic and isentropic changes, a distinction that is all too often ignored in text-books. The next two chapters deal with the essential preliminary of motion in one dimension, including isentropic channel flow and flow in Laval nozzles. This leads to a discussion of normal and oblique plane shock waves in the next chapter, where Mach waves are introduced as very weak disturbance fronts, and some discussion is given of condensation shocks. The flow in channels is then resumed in the following chapter, where the flow is not assumed to be isentropic, and the effects of shock waves and skin friction are discussed. This chapter concludes with a useful summary of the basic principles of supersonic wind-tunnel design. The next chapter discusses the standard optical methods of observing flow, namely, the striation, shadowgraph and interferometer methods. The general equations of motion are then developed in a chapter which includes a fairly complete restatement of the meanings of vorticity, circulation, stream function, and velocity potential in compressible flow. Then follows a discussion of the various methods of approximation that have been adopted to solve the general equations for isentropic flow. Thus the linearised theory for subsonic and supersonic flow occupies two chapters, another is devoted to methods of successive approximation, such as the Janzen-Rayleigh method, and there is a chapter to the hodograph method. Consideration of the linearised theory is confined to two dimensions, although its extension to some three-dimensional flow problems would have been a relatively simple matter. The chapter on the hodograph method is devoted largely to the Karman-Tsien approach, no mention being made of Temple's method, which is considered by many to be theoretically more acceptable. The next chapter discusses some exact solutions for isentropic flow, including what is now called the simple wave flow (Prandtl-Meyer flow), and Ringleb's solution for flow past a half-plane. The discussion links these solutions with singularities in the hodograph transformation and hence with the theory of limit lines, thus providing a simple but illuminating introduction to this difficult subject. The method of characteristics is dealt with in the next chapter in a manner that should be a model for future writers; hitherto the literature of the method has been unnecessarily obscure.

The final chapter deals very briefly with the effects of viscosity and touches on some of the problems of transonic flow. Useful shock-wave charts and a characteristics chart are provided in loose form in a holder in the back of the book. The printing, arrangement, diagrams and paper are up to the high standards set in the Galcit Aeronautical Series, of which this book is the fifth, and the price is notably moderate. Any future edition must inevitably contain revisions and additions, but the essential soundness of the present book should ensure that it remains of value for many years to come to all concerned with the flow of a compressible fluid.

*Cours de Mécanique.* Volume I. *Statique.* by PROFESSOR HENRY FAVRE. Dunod, 92, Rue Bonaparte, Paris, VIe. [Price 980 French francs.] Leemann Frères, 64, Stockerstrasse, Zürich.

THIS *Cours de Mécanique* is based on lectures given by Professor Favre at the École Polytechnique Fédérale, Zürich. It is to consist of three volumes, of which this, the first, is concerned with statics; the two that are to follow will be devoted to dynamics. Professor Favre divides his exposition into three parts dealing, respectively, with the statics of rigid, elastic and fluid bodies. Part I, which forms half of the book, begins with the composition and resolution of forces acting on a particle and derives the conditions for the equilibrium of a particle under the action of a set of forces. Then follow two chapters dealing with the conditions of equilibrium of an extended rigid body subject to systems of forces in two and three dimensions. The properties and vector character of couples are clearly explained and due prominence is given to graphical methods. There is a good chzpter on the flexure of bars, accompanied by diagrams of bending moments and shearing forces, and on the theory of frames, with an account of the standard procedures for their graphical solution wherein careful distinction is drawn between statically-determinate and statically-indeterminate systems.

As might be expected from Professor Favre's close connection with photo-elasticity, his treatment of the statics of elastic solids, in Part II, is outstanding. The theory of elasticity of homogeneous and isotropic solids involves the study of the distribution of forces in the neighbourhood of a point to determine the stresses, the study of the resulting small deformations to ascertain the corresponding strains, and the formulation of appropriate hypotheses to relate the stresses with the strains. Rigorous solutions of many problems in elasticity have yet to be found, but, thanks to the simplifying assumptions made in that branch of the theory of elasticity known to engineers as the resistance of materials, solutions satisfactory for practical purposes have been obtained for a number of important problems. How adequate these assumptions are in ordinary cases is well brought out in the diagrams on page 273, which afford a direct comparison of the stress trajectories calculated and obtained experimentally by the photo-elastic technique. After deriving the general equations of elastic equilibrium, Saint Venant's classical solution of the problem of the torsion of prisms is given. Consideration of stresses in cylindrical shells is omitted.

Part III dismisses hydrostatics all too briefly in ten pages, and considers only incompressible fluids. Though primarily theoretical, this course does include such practical matters as criteria of rupture and most of the examples have practical implications. The printing is excellent and the text appears to be remarkably free from misprints. The decision to place three or four figures side by by side across the page is hard to justify. The saving of paper must be small, and the figures themselves are difficult to follow without strain. The topics included are treated with admirable thoroughness and clarity, but there are some notable omissions, no mention being made of the method of virtual work, of the energy stored in strained bodies, of attractions, or of potential theory. Though it would seem logical to give consideration to some, at least, of these topics in a course on statics, it may be Professor Favre's intention to include them in his subsequent volumes.

*The Plating of Zinc Alloy Die Castings.* Zinc Alloy Die Casters Association, Lincoln House, Turl-street, Oxford; and Machinery Publishing Company, Limited, National House, West-street, Brighton, 1. [Price 7*s.* 6*d.*]

IN the introduction to this book it is noted that, in addition to the many variables in plating practice, platers have their separate methods of doing similar work. The form chosen for the book, a symposium covering the widest possible field, was therefore considered more valuable than straightforward recommendations of limited scope. There are four main chapters; on the production of castings for plating, plating, the maintenance of plating baths, and one of lists and specifications.

In the first of the principal sections, thoroughness is established as the basis for all successful plating, American practice being quoted for extreme care in determining optimum conditions for producing a satisfactory casting, and in insisting on conformity with those conditions during the production run. The same note recurs many times and gives rise to an interesting statement on the cost of producing good quality plated deposits. According to this, the maximum amount saved by producing a thin deposit instead of a good one is much less than 1 per cent. of the total production costs; but the result may be a 99 per cent. reduction in the life of the article. Although these figures may not be truly representative, even if they are really comparable, at least they draw attention to the difference between cheapness and economy. Appropriately, the text consists of references to published investigations and opinions, followed by highly compressed summaries of the present position stage by stage. Thus, on the blistering of copper deposits on zinc alloy, separate investigations by Castell, Carl, Wallbank, Anderson and Reinhard, Oplinger, Lewis, Sizelove, Maher, Petrocelli and Phillips lead to the conclusion that the formation of hard blisters is related to excessive hydrogen from the zinc surface; with the rider that electrolytic cleaning should be as rapid, and the acid dip as brief, as possible.

It is characteristic of the whole publication that, while easily accessible methods of test are omitted, recommendations for taking truly representative samples for both chemical and physical determinations are included. Considerable space is given to descriptions of filters for plating solutions, after Wernick and Silman, who are quoted as favouring a combination of the intermittent and continuous processes. The fourth main section gives tests for determination of the thickness of plated coatings and for the adhesion of electrodeposit; also a specification for thicknesses of deposits. A final chapter deals with stripping plated coatings, and an appendix gives typical procedures for plating. This is a serious text-book, of value to the expert, and particularly the experimenting, plater; it is unfortunate that it should be clad in a cover and dust-jacket that strongly suggest a beginner's popular handbook.

# BRITTLE FRACTURE IN MILD-STEEL PLATES—II.

(*Concluded from page 595.*)

WE conclude below our reprint of Dr. C. F. Tipper's contribution to the Conference on Brittle Fracture in Mild-Steel Plates, held at Cambridge, on October 26, 1945.

## DR. C. F. TIPPER'S PAPER (*Concluded.*)

Two plates welded together were sent under the reference number E.R. 9826/1. Both plates, which were sent by Mr. Boyd, showed fractures similar to those described already, although, in this case, they were known to have been caused by an underwater explosion. Only one plate was suitable for test-pieces and this had a slight curvature; the second plate, too, was curved. Cracks, shown in Fig. 74, on page 606, are similar to those found in Plates 1 and 3. The structure of this plate was normal regarding grain size and number and character of inclusions (Fig. 75, page 606). There were signs of distortion and absence of Neumann bands, and somewhat higher and varied hardness numbers, which suggests that the plate may have been cold-worked, possibly when being fitted during construction. This plate gave a brittle-type fracture at normal temperatures, but the breaking stress was as high as the ultimate stress for the normal test-piece.

Plate S.D. 413 was particularly dirty and laminated. Fig. 76, on page 606, shows typical inclusions, which were numerous. The grain size was medium and slightly smaller than Plate 3, as shown in Fig. 77, on page 606. The plate had not fractured in use, but was cut from a ship under repair; it was sent by Mr. Boyd. In notch tensile tests, it was ductile at 15 deg. C., the fracture was only partly crystalline at 0 deg. C., and was 100 per cent. crystalline at — 15 deg. C.

The material referred to as E.B. was available in ⅜ in. and ½ in. by 3 in. strip, and also in the form of bar of the same composition. The analysis is carefully controlled in all the forms used. It is used in all forms for teaching purposes and gives remarkably consistent results. The structure of the strip used in these experiments is shown in Fig. 78, on page 606. Compared with the other steels, it has an exceptionally fine grain and high Izod figures. The carbon content is lower than any of the ship-plates, yet the hardness number is higher, probably on account of the fine grain size. In notch tests, the fracture was always fibrous.

The carbon content of Plate Mur, which was sent by Messrs. Murex Welding Processes, Limited, was higher than any of the ship-plates. Fig. 79, on page 606, shows the structure, which was normal and satisfactory. Notch tensile tests produced a crystalline fracture at 0 deg. C. and partly crystalline at 15 deg. C.

The structure of Plate W is shown in Fig. 80, on page 606. It was free from undesirable inclusions, but was coarse-grained. The fracture of a notch tensile test was crystalline at 0 deg. C. and partly so at 15 deg. C. This plate was taken at random from a batch sent for welding experiments.

In further experiments with Plate 1, a strip ¾ in. wide was cut from it and extended 10 per cent. in a tensile testing machine. This strip was then cut into pieces for Izod tests and given the heat-treatments shown in Table III. The results are also given in Table III, and compared with a set of similarly treated specimens from a bar Mark R.A. which had the following percentage composition: 0·16 C., 0·24 Si, 0·78 Mn, 0·036 S, 0·041 P, 0·08 Ni and 0·08 Cr. Making allowance for the fact that the steel R.A. had a lower carbon content than Plate 1, the differences in properties after the same heat-treatment are striking. Even heating R.A. steel to 1,200 deg. C. and slowly cooling failed to make it brittle.

As a result of the experiments described, and from a study of the fractured plates, the following explanation may be tentatively put forward. Any irregularity in the plate edges may result in the starting of a small crack. The irregularity may take the form of a flame-cut edge, rough finish, accidental cuts or knocks, flaws in the plate, bad welds, or sharp angles, and discontinuities in design. The crack may remain quiescent until circumstances, such as heavy weather, increase the stresses in its immediate vicinity. If the steel is ductile, the crack will spread slowly and may stop altogether when the stress has been relieved. If the steel is in a brittle condition, due to low temperatures or poor quality, the crack may develop into a cleavage fracture which spreads at a high velocity and the magnitude of which may be limited only by the size of the plate, or several plates if welded. The plates of riveted ships are subject to some of the same faults at their edges, but a crack starting in these plates would tend to run into the first rivet hole and stop there. Hence, the liability of failure in riveted ships is far less than in welded ships.

Dr. Tipper pointed out that the report on brittle fracture of mild-steel plates, which she was introducing, contained the account of preliminary experiments up to the end of 1944. She continued: "We there show that these fractures were cleavage fractures, and that they were produced only when a notch was present (I am using the term 'notch' to mean any discontinuity, a notch in its very widest sense), and also when the temperature was sufficiently low. Since then, we have fractured strips up to 6 in. wide, and I understand that, in the United States, using a similar technique, fractures up to 6 ft. wide have been made. It soon became evident that different steels behave differently, particularly with regard to the temperature at which these brittle fractures occur. Above a certain temperature they are ductile, while below it they give cleavage fractures, under similar conditions of test. I have now done tests on five different ship plates and a rimming steel, and propose to summarise our latest results. Before that, however, I am going to show a film which we have made here illustrating some of these tests.

"The tests were made on 3-in. wide strip, having a 45 deg. angle notch, ½ in. deep on one edge or both edges. They were pulled in a normal tensile testing machine. This test originated in my efforts to reproduce the fractures which we found in actual ship failures and was intended to resemble stress conditions in such structures better than the more usual notch impact or notch bend tests. Moreover, the fact that the s.s. Schenectady broke in half while lying in dock removes any possibility that these are essentially impact fractures. It is also possible to get more information out of one test of this type than out of any other single test."

Dr. Tipper then showed the film, and in doing so mentioned that the photographs were taken at 64 frames per second and were being shown at 20 per second. The first test was on a 'lack mild-steel plate used in the Engineering Department, and was typical of an extremely ductile steel. Where the test was conducted at normal temperatures, the crack started at the notch and gradually proceeded across the section with considerable absorption of energy. The next test was with the same steel at a temperature at yield of —35 deg. C. and again gave a similar type of fracture. The succeeding tests were carried out on actual samples of plate at two temperatures and showed the opening of the notch and change of shape from > to ⊃, the fracture spreading slowly across the strip at normal temperatures, and the very sudden fracture, also following change of shape of the notch, which resulted when the temperature was lowered. Fracture occurred in these cases between one picture and the next and had the characteristics of all cleavage fractures. Figures of yield stress and ultimate at the two temperatures did not differ to

TABLE III.—FURTHER EXPERIMENTS WITH PLATE I.

| Treatment. | Izod Impact Test, Ft.-lb. | Fracture. | Vickers Hardness Number. |
|---|---|---|---|
| PLATE 1— | | | |
| As received | 39, 40, 45 | 50 per cent. crystalline | 115–120 |
| 10 per cent. extension | 13 (mean) | Crystalline | 155 |
| 10 per cent. extension heated to 900 deg. C. | 41 (mean) | 50 per cent. crystalline | 120 |
| 10 per cent. extension heated to 1,000 deg. C. | 80 (mean) | 50 per cent. crystalline | 117 |
| 10 per cent. extension heated to 780 deg. C. | 20 (mean) | Crystalline, coarse | 112 |
| 10 per cent. extension heated to 900 deg. and then to 780 deg. C. | 44 (mean) | 50 per cent. crystalline | 113 |
| R.A.— | | | |
| Normalised | 104 | Bent | 188 |
| Extended 10 per cent. | 43, 67 | Brittle, but not crystalline | 203 |
| Extended 10 per cent. heated to 780 deg. C. | 103 (mean) | Bent | 188 |
| Extended 10 per cent. heated to 950 deg. C. | 100 (mean) | Bent | 182 |

TABLE IV.—PARTICULARS OF PLATES USED FOR TESTS.

| Plate No. and Source. | Samgona 3 | S.D. 413 | Colville's. 1. | Colville's. 4. | Colville's. 5. | Dorman Long |
|---|---|---|---|---|---|---|
| Method of manufacture | — | — | basic open-hearth | acid open-hearth | acid open-hearth | Rimming type |
| Nominal thickness, in. | 0·339 | 0·410 | 0·560 | 0·510 | 0·560 | 0·555 |
| ANALYSIS. | | | | | | |
| Carbon Per Cent. | 0·20 | 0·18 | 0·19 | 0·22 | 0·17 | 0·07 |
| Silicon " | <0·02 | 0·05 | 0·07 | 0·17 | 0·06 | 0·009 |
| Sulphur " | 0·034 | 0·04 | 0·028 | 0·045 | 0·039 | 0·048 |
| Phosphorus " | 0·038 | 0·022 | 0·010 | 0·039 | 0·050 | 0·034 |
| Manganese " | 0·38 | 0·33 | 0·58 | 0·72 | 0·41 | 0·39 |
| Nickel " | trace | trace | 0·13 | 0·21 | 0·14 | 0·23 |
| Chromium " | 0·10 | trace | 0·05 | 0·09 | 0·05 | 0·03 |
| Molybdenum " | nil | nil | 0·02 | 0·035 | 0·02 | 0·03 |
| Copper " | 0·10 | 0·20 | 0·08 | 0·13 | 0·10 | 0·11 |
| Arsenic " | nil | nil | 0·021 | 0·025 | 0·022 | nil |
| Tin " | <0·02 | nil | 0·018 | 0·028 | 0·018 | nil |
| Aluminium " | 0·005 | 0·012 | 0·008 | 0·006 | 0·003 | 0·006 |
| Alumina " | 0·019 | 0·009 | 0·011 | 0·014 | 0·012 | 0·004 |
| Nitrogen " | 0·005 | 0·004 | 0·0055 | 0·0025 | 0·0013 | 0·003 |
| Oxygen " | 0·0175 | 0·009 | 0·010 | 0·001 | 0·010 | 0·0095 |
| Hydrogen " | 0·0001 | 0·0001 | 0·0001 | 0·0001 | 0·0001 | 0·0001 |
| Transition temperature, deg. C. | 15 | −20 to −8 | −20 to +2 | −12 to 0 | 0 to +10 | L. below −61·7<br>K. −35 to −25 |
| *Normal Tensile Tests at Room Temperature.* | | | | | | |
| Yield stress, tons per sq. in. | 20·6 | 17·0 | 16·2 | 19·4 | 16·8 | 14·5 L.<br>14·6 X. |
| Ultimate stress, tons per sq. in. | 28·0 | 26·5 | 28·4 | 32 | 28 | 20·7 L.<br>21·8 X. |
| Elongation, per cent. on 4 in. | 25 | 37·5 | 23 | 21 | 24 | 45·5 L.<br>36 X. |
| Reduction in area, per cent. | 45 | 61 | 59 (on 8 in.) | 49 (on 8 in.) | 48 (on 8 in.) | 75 L.<br>60 X. |
| Vickers hardness number | 125-140 | 115-140 | 135 | 150 | 133 | 112 |
| Number of grains per sq. mm. | 2,300 | 2,000 | 2,300 | 2,450 | 1,800 | 2,300 L.<br>2,300 X. |

# BRITTLE FRACTURE IN MILD-STEEL PLATES.

FIG. 74. E.R. 9826. NEAR FRACTURE. × 150.

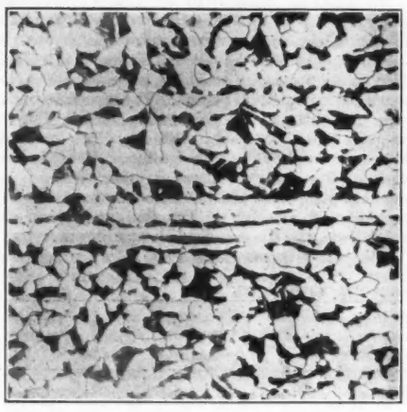


FIG. 75. E.R. 9826. × 150.

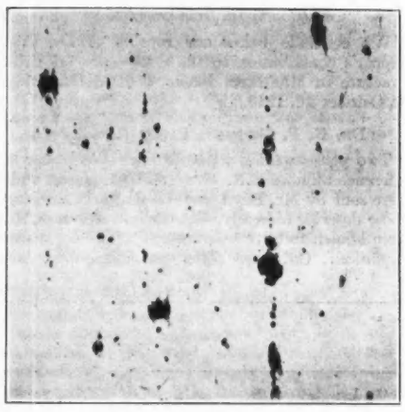


FIG. 76. PLATE S.D. 413. × 150.

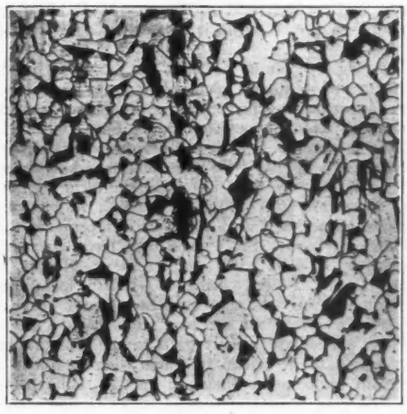


FIG. 77. S.D. 413. × 150.

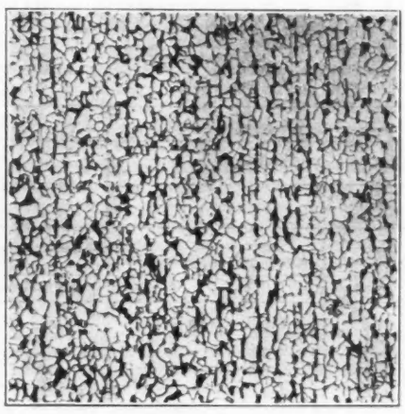


FIG. 78. E.B. × 150.

FIG. 79. MUR. × 150.

any extent, but elongation was down in test-pieces showing cleavage fractures.

After the film, Dr. Tipper continued: "All our tests are now carried out on a test-piece of standard shape, generally 1 in. wide with two 45-deg. angle notches, ¼ in. deep, but some 3 in. wide strips were included to show the effect of width. Altering the dimensions of the test-piece or notch seems to have very little effect on the transition temperature, but we have no information on the effect of much larger dimensions, and information coming from the United States suggests that the transition temperature may then be raised. Our results show that, in general, the yield stress and ultimate both increase as the temperature is lowered. We cannot detect the yield with dividers or dropping of the beam until the main body of the material has yielded, so that, in future, we propose to calculate the yield on the un-notched area. If we do this, then the figures for yield stress lie on the same curve with the un-notched test-pieces tested at the same temperatures. The effect of increased width, that is, up to 3 in., is to lower the ultimate in most cases. A possible explanation is that fracture ensues when the stress at the notch reaches a certain value, which may be far higher than the mean stress on the test-piece.

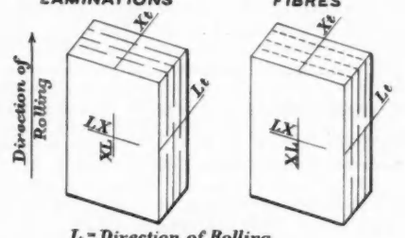
The change from a wholly fibrous to a wholly brittle fracture is usually separated by a temperature range over which the fractures are partly one and partly the other. The extent of this range varies from steel to steel. There is no corresponding break in the values of yield and ultimate, but there is often a drop in elongation and reduction in thickness of the strips, which coincides with the change in appearance of the fractures. The effect of normalising, pre-straining and ageing has been studied in some plates, and it has not been found

FIG. 80. PLATE W. × 150.

that, in the steels tested, these treatments alter the transition temperature, except to lower the upper limit of the transition temperature in one case, although they increase both yield and ultimate at the expense of ductility, after ageing.

The influence of direction of rolling varies with the material. It is slight in most of the plates, but is particularly marked in the case of the rimming steel. In this steel, notched test-pieces cut across the direction of rolling gave cleavage fractures at −30 deg. C., but in the long direction they were still not developed at −60 deg. C. A comparison has been made between the Izod test and the notch tensile test to see if any difference

PLATE WITH LAMINATIONS — Fig. 81. — PLATE WITH FIBRES




*L* = Direction of Rolling
*X* = Cross Direction
*t* = Thickness of Plate
*Lt* = Specimen Cut in Direction L
Notch Cut in Direction t
*Xt* = Specimen Cut in Direction X
Notch Cut in Direction t
Etc.

exists between the transition temperature range in these steels determined by both methods of testing. The transition temperatures as shown by the Izod tests are lower and the gradual fall in energy-to-fracture figures is less striking than the changes observed in the notch tensile tests.

An attempt has been made to correlate transition temperature in these steels with composition, grain size, etc. The results of analyses of these steels are not quite complete; it is hoped to be able to include a similar diagram for oxygen* content shortly. The only consistent rise in transition temperature with increase of an element is seen to be that showing change with carbon content, and I think that the effect of carbon should be looked into further.

* Oxygen content is given in Table IV, on page 605.

Although fine grain size is considered to confer less susceptibility to notch brittleness, there is little to indicate that it has much influence on the transition temperature. This conclusion is further supported by the results obtained in the case of the rimming steel. Here, we have the same composition and grain size, but two entirely different transition temperatures related only to the direction of rolling. X-ray analysis, carried out for me at the Cavendish Laboratory, failed to find any suggestion or preferred orientation.

The explanation is to be found in the differences between a laminated and a fibrous structure, such as are illustrated in Fig. 81, opposite, and the position of the notch both in Izod and notch tensile tests in relation to the structure.

So far, our results are chiefly negative, but an investigation of six steels only is not sufficient upon which to base any definite conclusions. I think we have shown that temperature is the most important single item and that, if cleavage fractures occur in a steel at high atmospheric temperatures, then the steel is dangerous. But the differences for which we are looking are so small that a few degrees change in temperature or slight differences in stress distribution in the same test-piece may be just enough to turn the scale.

## LAUNCHES AND TRIAL TRIPS.

M.S. "AMBOIM."—Single-screw general cargo liner, carrying 12 passengers, built by the Burntisland Shipbuilding Company, Limited, Burntisland, Fife, for the Companhia Colonial de Navegaçao, Lisbon. Main dimensions: 442 ft. by 59 ft. by 38 ft. to shelter deck; deadweight capacity, 9,270 tons on a load draught of 26 ft. approximately. Four-cylinder opposed-piston Doxford Diesel engine of 4,400 b.h.p., giving a time speed of 15 knots. Trial trip, May 20.

M.S. "BRITISH RANGER."—Single-screw oil tanker, built and engined by Messrs. Harland and Wolff, Limited, Govan, Glasgow, for the British Tanker Company, Limited, London, E.C.2. Main dimensions: 463 ft. by 61 ft. 6 in. by 34 ft.; deadweight capacity, about 12,280 tons. Harland-B. and W. six-cylinder four-stroke single-acting Diesel engine, giving a loaded speed of 12 knots. Trial trip, June 2 and 3.

S.S. "BELEVELYN."—Single-screw cargo vessel, built by Messrs. John Readhead and Sons, Limited, South Shields, to the order of the Belships Company, Limited, Oslo. Main dimensions: 370 ft. by 60 ft. by 37 ft. 6 in. to upper deck; deadweight capacity, about 8,000 tons on a draught of 24 ft. Fredriksstad steam motor of 3,160 i.h.p., built under licence by Messrs. John Readhead, with two Foster Wheeler water-tube boilers built by Messrs. Richardsons, Westgarth and Company, Limited, West Hartlepool. Speed, 13 knots. Launch, June 8.

M.S. "BRITISH STRENGTH."—Single-screw oil tanker, built and engined by Messrs. Harland and Wolff, Limited, Belfast, for The British Tanker Company, Limited, London. Main dimensions: 463 ft. by 61 ft. 6 in. by 34 ft.; deadweight capacity, about 12,280 tons on a summer draught of 27 ft. 7 in. Burmeister and Wain six-cylinder four-cycle engine, of 3,200 b.h.p. in service, built by Messrs. John G. Kincaid and Company, Limited, Greenock. Launch, June 9.

S.S. "ERNEST HOLT."—Fishery research vessel, built by Messrs. Cochrane and Sons, Limited, Selby, Yorkshire, for the Ministry of Agriculture and Fisheries. Main dimensions: 175 ft. by 30 ft. by 16 ft. Triple-expansion engines constructed by Messrs. Amos and Smith, Limited, Hull. The vessel will be used in Arctic waters to study fish biology and new types of insulation and fish-room construction. Launch, June 9.

S.S. "PRESIDENT DE CAZALET."—Twin-screw passenger and cargo vessel, built by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Newcastle-upon-Tyne, to the order of the French Government, for the Compagnie de Navigation Mixte, Marseilles. Main dimensions: 402 ft. by 53 ft. 6 in. by 27 ft. 3 in.; deadweight capacity, 2,162 metric tons on a mean draught of 19 ft. 6¾ in. Parsons single-reduction geared turbines installed by the shipbuilders, with two Lamont oil-fired boilers supplied by Messrs. John Thompson Watertube Boilers, Limited, Wolverhampton. Speed on trial, 22 knots. Trial trip, June 14.

## EXPORT VEHICLE DESIGN.*

By H. W. FULTON, B.Sc.(Eng.), M.I.Mech.E.

(*Concluded from page* 595.)

ALL axles must have wheels at approximately the same track spacing, in order that they may follow each other correctly in soft ground and so save expenditure of power in breaking down fresh tracks. Water splashes at creeks where there are fords but no bridges require the ignition equipment to be reasonably protected, and because such creeks seem inevitably to have rather steep approach and departure gradients, avoidance of undue front and rear overhang is necessary to obviate fouling. Sufficient clearance to permit the use of chains under bad road conditions, may also be required if wet-weather running is necessary; mudguards must be arranged accordingly. Heavily cambered roads can result in trouble with oil leaks, probably along axle shafts. As such roads are often associated with hot-weather conditions, in which lubricants are at their thinnest, special attention should be paid to sealing arrangements. Where graded or scraped earth roads are found, apart from the seemingly inevitable corrugations, there are potholes which, developed during a rainy spell, have become lightly filled with scraped dirt and are no longer visible to the driver. These give rise to very considerable impact loadings, and call for higher factors of safety than are usual on axle bodies and springs.

It is necessary to know the maximum gradient involved, and the rolling resistance of the road surface, before the ability of the vehicle to climb the gradient can be assessed. A rolling resistance of 80 lb. per ton is probably sufficient for normal unmetalled road surfaces, but sand or mud is liable to raise this figure to 200 lb. per ton or more. The significance of rolling resistance is increasingly important the lower the power/weight ratio of the vehicle and the higher the gear used. The heavier commercial vehicles quite normally have gross tractive efforts below 100 lb. per ton in top gear, whereas in the lowest gear they may have 600 lb. to 900 lb. per ton. If 100 lb. per ton gross tractive effort is available, an increase of rolling resistance from 60 lb. per ton to 80 lb. per ton reduces the net tractive effort available for acceleration or hill climbing from 40 lb. per ton to 20 lb. per ton—halving the performance of the vehicle in top gear. In bottom gear, if 600 lb. (gross) per ton is available, it is reduced only from 540 lb. per ton to 520 lb. per ton. Not only, therefore, must the maximum gradient be known, but the frequency of all gradients and the length of any one are important in certain cases. The author feels there is a tendency to pay too much attention to gradient performance in the lower gears, and too little to performance in higher gears. This amounts to a plea for bigger engines, the existence of which is so penalised, in the United Kingdom, by restrictive taxation.

A cross-sectional elevation of the route may be required, and it is helpful to know whether the main load-carrying function is to be uphill or downhill. Overseas, much use is made of road transport as feeder services to relatively infrequent railway lines. If these lines run in valleys, mainly to transport material from the surrounding country to some point on the railway, more attention has probably to be paid to the braking and control of the vehicle downhill than to the performance uphill. Conversely, if the railway lines are on high ground and draw material from the surrounding low ground, good hill-climbing ability with full load is essential, and braking is not so vital. Mountainous terrain must be associated with acute corners, often limiting the size of vehicle to be employed; a good turning circle is therefore very important. In mountainous districts, the choice of the gear ratio repays attention. To be unable to speed up the vehicle sufficiently to permit a change into a higher gear is most aggravating on a long climb; a compromise has to be achieved between the close-ratio gearbox with many steps, confusing the driver, and the simpler form with fewer, wider steps. There should be equal steps between successive gears if damage by ordinary drivers is to be avoided. On the descent of roads where the surface is of relatively slippery clay, usually with an escarpment, the one thing which must be avoided is a front-wheel skid, and provision for cutting out the operation of the front-wheel brakes under these conditions may be a useful feature.

Maximum and minimum temperatures, and the range likely to be encountered in any short period of operation, are important. If the range is considerable, some means of controlling engine operating temperatures will be necessary, but this means will involve extra complication and will sooner or later require maintenance—it is not ordinarily a desirable feature. It is assumed that provision will be made for running under the worst conditions of high temperature encountered; altitude may, however, play a considerable part, through the reduction in the boiling point both of water and of fuel. It is helpful to know the annual amount of rain expected in an area, and also the manner of its falling. Violent tropical rain storms necessitate weatherproofing of the vehicle, and are likely to have adverse effects on road surfaces. The water may contain strange impurities; apart from their corrosive effect they may cause depositions, giving rise to mechanical obstruction. Radiators and thermostats in particular are victims of such attack. Local features may include fog, sand or dust storms, insects or snakes; each of these needs attention in design. Sand storms require special methods of protection for the engine, while the external choking of radiators by insect life predisposes one to a design in which the face of the radiator is accessible for cleaning; if it is sufficiently accessible, birds may carry out the cleansing process while the vehicle is parked.

In the matter of speed there is marked disparity as between home requirements and those of overseas customers. Economic stringency in the United Kingdom has for years placed the emphasis on economical running, and, at least so far as the petrol engine is concerned, this is most readily achieved with the use of the smallest reasonable engine for the duty involved. Neither our roads nor our traffic conditions permit high speeds, but where distances to be covered are much greater and where the roads and traffic conditions permit high speeds, much greater engine power is needed, and overseas users have become accustomed to a level of performance much higher than is acceptable for home vehicles. Additional engine power is required to compensate for loss of power at high altitudes; vacuum servo-brakes also lose power at altitude. The author allows about 3 per cent. loss per 1,000 ft., which is an ample figure.

It is necessary to note the life mileage and the annual mileage expected from the vehicle; and the relative cost of petrol and fuel oil in the territory largely determine the type of engine to be supplied. Loss by evaporation of petroleum fuel can become quite a serious factor in hot climates, and loss by pilferage must not be forgotten. In certain areas, the black-market value of stolen petrol is so much higher than that of stolen fuel-oil that this factor alone can determine the design in favour of the Diesel type. Fuel-tank caps that can be padlocked may be required; in any case, they should be of a type not readily detachable. Native drivers are notoriously careless, and sometimes lazy: they are content to remain in the driving seat while their tank is filled up by an equally careless attendant, who probably does not bother to see that the cap is properly replaced. Consequent running with no cap, or with a piece of dirty rag as a substitute, tends to allow dirt into the system, and the dirt will tax even the over-size filter which ought to be incorporated in the fuel line.

In some overseas markets, low first cost takes precedence over all other factors affecting the purchase of vehicles; in others, reliability under protracted conditions of bad maintenance is important. The importance of a low overall running cost does not seem to have been fully appreciated in most overseas operations. The nature of the loads to be carried must be known, as well as the local views on overloading. In some countries there are strict government regulations determining the load which may be carried, usually related to tyre capacity or to the vehicle manufacturer's declaration of the proper rating. In other countries overloads of 50 per cent., or even 100 per cent., are permitted. Vehicles must be rated with due regard to the usage that will be made of the rating within the area.

Distances between filling stations are commonly very great, by home standards, and fuel tanks must be large enough to permit running without danger or discomfort over these distances. A 300-mile tank capacity is always desirable, and a 400-mile capacity is better. If vehicles are used, as they frequently are, from railhead out and back to railhead, it may be found that the price of fuel at the railhead is considerably less than that at a point 200 miles distant, and being able to complete the return journey on one filling of fuel is an advantage. A really large tank scores in countries with a rigorous five-day week, where petrol cannot be obtained from Friday night till Monday morning. So far as cars are concerned, the provision of adequate space for baggage or camping kit is very desirable, and passengers should not be cramped together in hot climates. The ability to provide skilled labour and spare parts for after-sales service is undoubtedly a very essential feature. Proper provision is immensely aided by design; simplicity is the keynote of all good design and pays handsome dividends in service, as does the use, wherever possible, of common parts for different models. Enough has been said to show that the only possible answer to all the different conditions lies in compromise, and, because the results of the compromise are so fundamental to our ability to meet competition overseas, the author stresses again the tremendous need for knowledge of conditions by those making the final decisions.

* Paper read at the Summer Meeting of the Institution of Mechanical Engineers, Automobile Division, at the Royal Technical College, Glasgow, on Wednesday, June 16, 1948. Abridged.

# PRE-STRESSED CAST-IN-SITU CONCRETE BRIDGE.

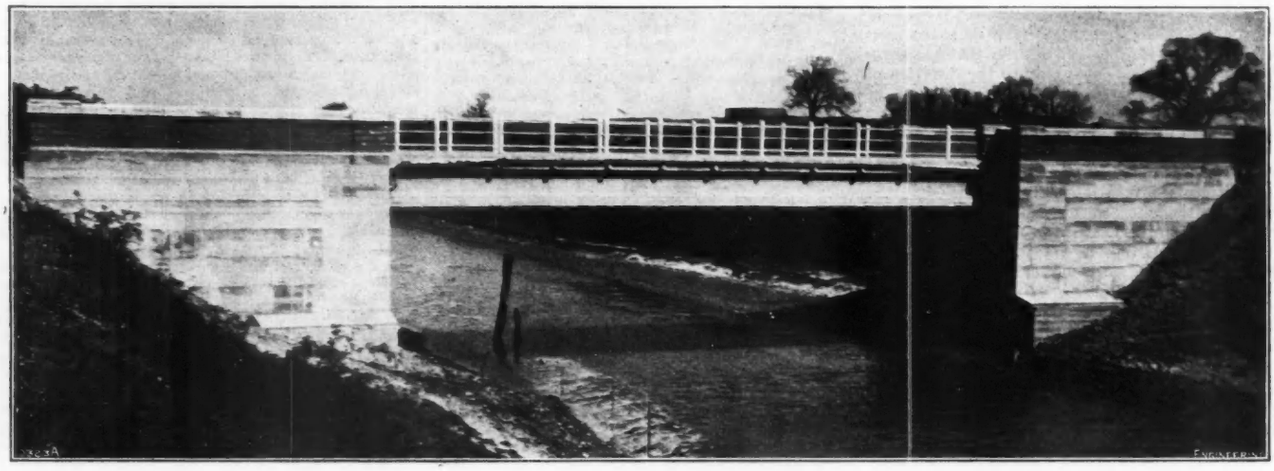


FIG. 1. VIEW OF COMPLETED BRIDGE.

## PRE-STRESSED CAST-IN-SITU CONCRETE BRIDGE.

WE have received from the Cement and Concrete Association, 52, Grosvenor-gardens, London, S.W.1, particulars of the new pre-stressed concrete Nunn's Bridge which has been completed recently over the Hob Hole drain at Fishtoft, near Boston, Lincolnshire. The Association state that it is the first pre-stressed concrete cast *in situ* highway bridge to be built in this country. It has an effective span between bearers of 74 ft., and the depth of the main girders is 4 ft. 2 in. Fig. 1, on this page, shows the completed bridge, and Fig. 2 shows it in course of construction, with the main beams cast but not pre-stressed.

When the Witham Fourth District Internal Drainage Board were faced with the problem of replacing the damaged three-span brick bridge, built by John Rennie about 140 years ago, there were several factors to take into account. Floods are a serious problem in the Fen country; therefore it is essential to avoid obstructing the free flow of water in rivers and drains. Hump-backed bridges, which were formerly suitable in this respect, are dangerous for modern traffic. Intermediate piers reduce the depth of a beam bridge, and thus provide additional depth for the passage of flood water. The piers themselves, however, are an obstruction, and a single-span bridge is therefore most suitable if the width of the river will permit it. The new bridge was required to carry present-day traffic loads, and, as often happens in the Fens, the foundations of the old abutments were not reliable, and it was therefore necessary to strengthen them with piles to prevent settlement. It was decided that a pre-stressed concrete bridge would be the most suitable design; the depth of beam could thereby be kept to a minimum, and the total weight, and the weight of steel, would be comparatively small.

The general arrangement of the bridge is shown in Figs. 3 and 4, opposite. It will be seen that there are five parallel beams (which are pre-stressed), 4 ft. 6¾ in. between centres, and five cross stiffeners, including one at each end. One end stiffener bears on a 2-in. by ½-in. bar rocker, and the other on a 2-in. diameter round bar. Both rest on new reinforced-concrete walls embedded in mass concrete which strengthens the old abutments. Ten 12-in. by 12-in. pre-cast concrete piles were driven in a row near the edge of each abutment, to a nominal depth of 28 ft. below Ordnance datum, and a line of Larssen 1 G.B. steel sheet piles was driven as shown in Figs. 3 and 4. The reinforced-concrete walls were constructed on the tops of the concrete piles.

When the old bridge spans had been demolished and the abutments strengthened, the new beams were cast on a timber deck laid on steel girders (trussed to increase their stiffness) which were supported on the old piers, as shown in Fig. 10, on page 612. Each beam was provided with 12 pre-stressing cables, placed as shown in Figs. 5, 6, 7 and 8, opposite. The cable was made up on site. It consisted of 12 0·2-in. diameter high-tensile steel wires laid longitudinally around a coil of wire, as shown in Fig. 9, opposite. The coil was made of 16-s.w.g. steel wire wound with the coils close, on a ¼-in. diameter core, and subsequently stretched to ½-in. pitch. To prevent the cables from coming into contact with the concrete, they were enclosed in a sheath of 30-s.w.g. strip, 5 in. wide, bent into a tube and joined by a longitudinal seam. The diameter of the cables, without sheath, was approximately 1 in. A simple method of assembling the coil, the 12 wires, and the sheath, in lengths of about 80 ft. on long benches, was devised. The pre-stressing of the cables was not carried out, of course, until the beams, stiffeners, and deck had been cast.

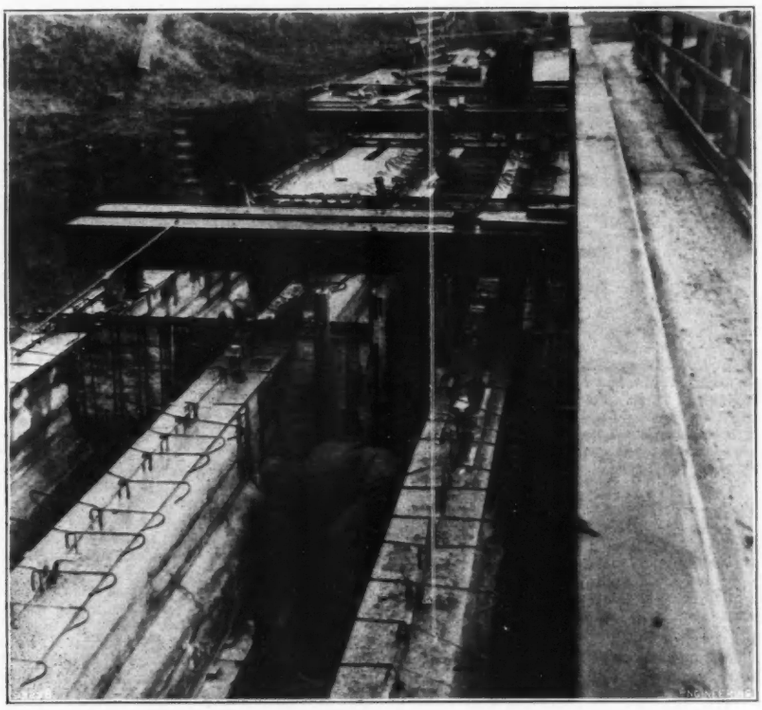
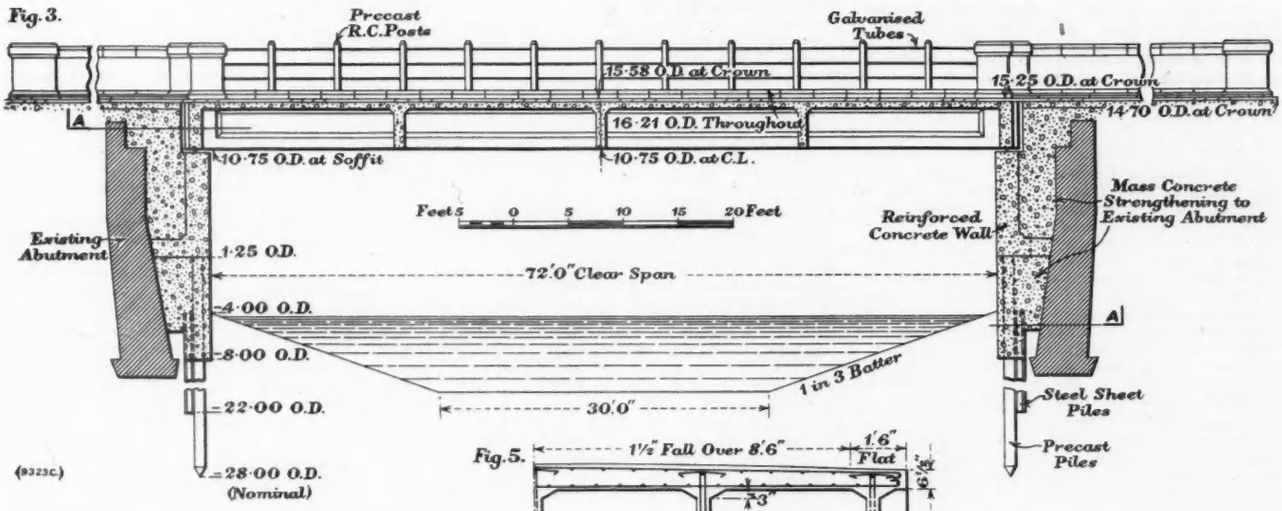


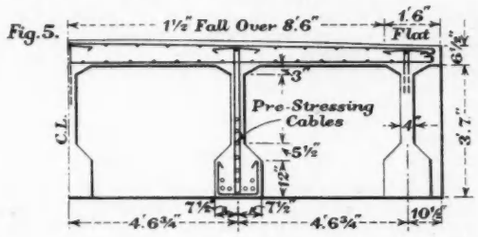
FIG. 2. CONSTRUCTION OF BEAMS AND STIFFENERS.

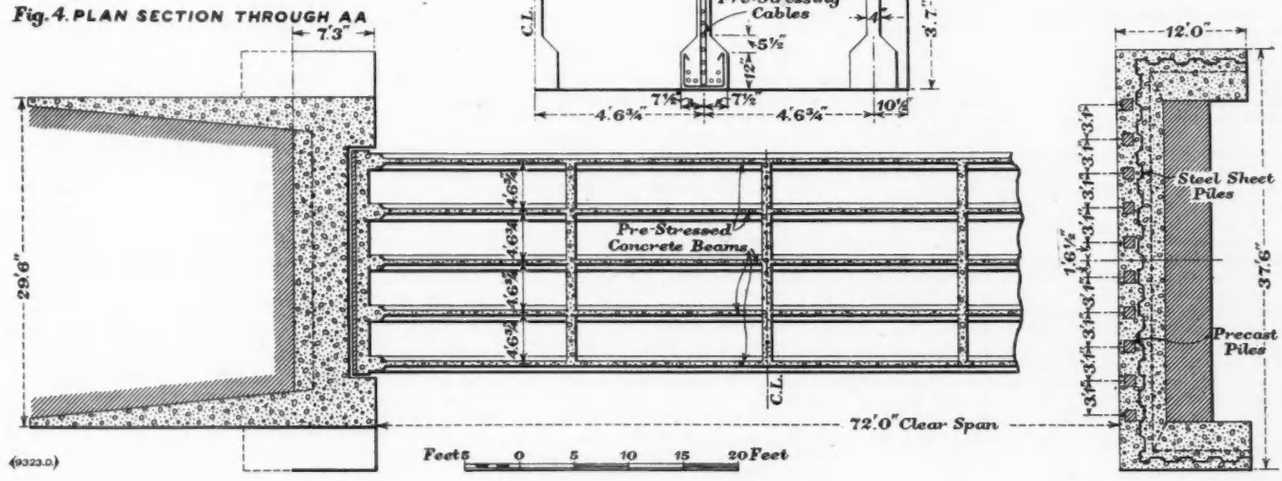
The concrete, which was specified to contain 28 lb. of cement per cub. ft. of finished concrete, was cast in sections in the normal manner. The beams were cast first, and then the stiffeners. The end stiffeners are 12 in. thick, and the three intermediate stiffeners are 9 in. thick. Ordinary steel reinforcement was incorporated in the beams, stiffeners and decking; the disposition of some of it is shown in the half cross-section in Fig. 5. The reinforcement in the intermediate stiffeners consisted of vertical ⅜-in. bars at 9-in. centres, linking two horizontal 1-in. bars at the top to two at the bottom. The reinforcement in the end stiffeners was ⅜-in. vertical (6-in. centres) and horizontal (4-in. centres) bars, linking 1-in. bars. The appearance of the underside of the bridge is shown in Fig. 11, on page 612.

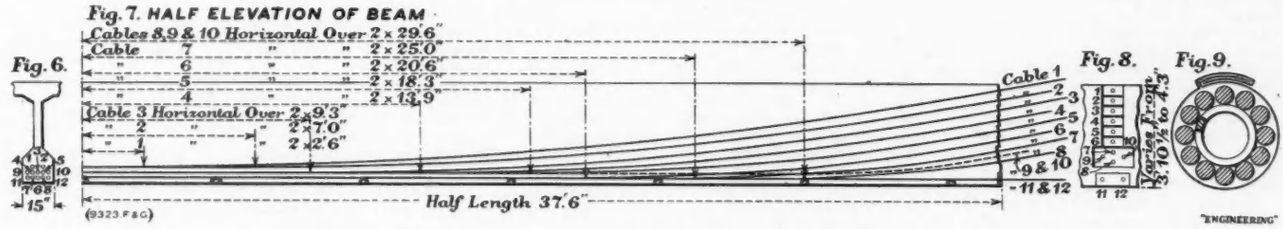
Pre-stressing was commenced when the concrete had reached a specified strength of 6,000 lb. per square inch. This was attained after about 18 days; the aggregate and sand were carefully graded, and the water : cement ratio was 0·47. External vibrations were used during pouring. The load on each cable was applied by hydraulic jacks, as shown in Figs. 12 and 13, on page 612. The order in which the cables were stressed was from the lower to the upper cables; two cables were stressed in one beam, then similar pairs were stressed in the other beams before passing on to the next higher pair in the first beam. The stress in each wire was nearly 70 tons per square inch, which corresponded to a load of approximately 2·2 tons on each wire, or 26 tons on each cable. The load was applied simultaneously by a jack at each end of the cable, and each end was then locked by forcing a cone into a socket with a force of about 20 tons applied by a secondary jack. The wires passed between the cone and the socket, and each socket bore on a steel plate bolted to the concrete (Figs. 7 and 8). It will be appreciated that, owing to the disposition of the cables, the effect of pre-stressing would be to impart a reverse loading to the bridge. In fact, the centre of the bridge rose

# PRE-STRESSED CAST-IN-SITU CONCRETE BRIDGE.




⅛ in. An initial compression calculated to be nearly 2,000 lb. per square inch, was thus induced in the bottom flanges of the beams, and a compression of slightly over 100 lb. per square inch was induced in the deck. This meant that a British Standard loading train (B.S. No. 153, Parts 3, 4 and 5 (1937), Appendix No. 1 (1925)) placed on the bridge, would be just sufficient to overcome the compression in the bottom flanges of the beams. With normal traffic passing over the bridge, the concrete of the bottom flanges will not reach a state of tension. Overloading, short of destruction, would normally cause temporary cracks to appear, which would close up on removal of the load.

The weight of the bridge structure proper, i.e., beams, stiffeners and deck slabs, is approximately 140 tons. The designed superimposed load, comprising a British Standard unit loading for highway bridges, the road surfacing, parapets and coping, amounted to 205 tons. The bridge was designed to support a load of 220 lb. per square foot of carriageway, together with a knife-edge load of 2,700 lb. per foot width of carriageway. After pre-stressing, the cables were grouted under pressure. The cables being hollow, they were first filled with water to expel all air and prevent any air being trapped in the grouting. A cone-shaped vessel containing the grouting was connected at its lower, pointed end, to one end of the cable, so as to feed the grouting through a hole in the locking cone. Compressed air was then admitted to the top of the vessel, and thus grouting was forced into the cable, expelling the water at the other end.

The concrete deck varies in thickness throughout its length and breadth, so as to provide a camber of 4 in. in the centre of the bridge in relation to the ends above the bearers. Tarmac, 3 in. thick, was applied to the carriageway. The principal levels, in relation to Ordnance datum, are shown in Fig. 3. The design and supervision of the pre-stressing work were carried out, in accordance with the Freyssinet process, by the Pre-Stressed Concrete Company, Limited, 131, Victoria-street, London, S.W.1, on behalf of Messrs. L. G. Mouchel and Partners, Limited, 36 and 38, Victoria-street, London, S.W.1, who were the consulting engineers for this work. The reconstruction work was carried out by the Witham Fourth District Internal Drainage Board, under the supervision of Mr. Gilbert E. Buchner, D.L.C., A.M.I.C.E., engineer to the board, and Mr. A. J. A. Roseveare, B.Sc., A.M.I.C.E., deputy engineer.

WHITE CITY STATION; LONDON TRANSPORT.—The new covered way for the westbound Central Line track, at the south end of the London Transport White City station, will be opened to traffic on the night of Saturday, July 17. The covered way is 220 yards in length, and passes below some buildings and the Hammersmith and City line. The construction of the station, which replaced the old Wood Lane station, was described on page 8, *ante*.

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PRE-STRETCHING ESCALATOR HANDRAILS.—We have received from London Transport particulars of a machine which they have constructed for stretching escalator handrails, which consist of several plies of cotton duck, bound and held in shape by rubber, and vulcanised. The handrails normally stretch about 3 or 4 per cent. in length when fitted to the escalator, and although means of adjusting the tension of the handrail are provided, it is desirable to eliminate the initial stretch before fitting. The machine will accommodate four handrails, each of which is propelled around two pulleys. One of the pulleys is driven by a motor, but is fixed axially. The other is free to move on rollers, and the tension is applied to the handrail by a weight connected to the spindle of the movable pulley.

## BRITISH STANDARD SPECIFICATIONS.

**THE following publications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.**

*Sound Insulation.*—The Codes of Practice Committee for Civil Engineering, Public Works and Building have now issued, in final form, Chapter III of the Code of Functional Requirements of Buildings, entitled "Sound Insulation (Houses, Flats and Schools)." The publication examines the problem of noise in buildings, whether from outdoor or indoor sources, and gives recommendations for treatment. The necessity for the initial consideration of the problem in the planning stage of building is stressed, both as regards choice of sites and the selection of materials. Methods of abatement of indoor noises by various types of construction and other measures, are described in the Code. Several diagrams illustrating these methods are included, as are also tables, based on the results of experiment, giving data on the loudness of noises on the phon scale. [Price of the publication, reference No. C.P.3—Chapter III (1948), 2*s.*, postage included.]

*Treatment of Water for Marine Boilers.*—A new specification, B.S. No. 1170, is a code of practice intended as an introduction to water treatment for marine boilers. At the request of Lloyd's Register of Shipping a sub-committee of the Institution was appointed some time ago to consider whether greater attention to well-established principles of boiler management, combined with the chemical treatment of boiler water on modern lines, could be recommended. The results of this inquiry are given in the new publication under two heads, namely, engineering factors and chemical factors. In a general introductory section, the need for the education and training of seagoing personnel and instruction in the control of treatment by testing is stressed. The section on engineering factors deals with the maintenance of boiler plant at full availability and gives guidance on those matters of detail which are likely to bring about contamination of the boiler feed water if neglected. In the chemical section, that method of boiler-water treatment by which the scale- and corrosion-forming salts are destroyed by alkaline reagents, with or without the use of an organic coagulant is described. Three methods of water treatment are prescribed. It is pointed out that the arbitrary plan of dividing treatment into three classes, applicable to the main types of boiler commonly installed on board ship and to feed water of varying quality, is open to some objections on purely technical grounds, but it is felt that these are outweighed by the practical advantage gained in simplifying the procedure for the seagoing engineer. [Price 10*s.* 6*d.*, postage included.]

*Universal Decimal Classification.*—The complete English edition of the Universal Decimal Classification is being prepared and published, section by section, by the British Standards Institution, at the joint request of the British Society for International Bibliography and the Association of Special Libraries and Information Bureaux. This has the approval of the Educational Foundation, Lake Placid Club, New York, the publishers of the Dewey Decimal Classification. The Universal Decimal Classification is an extension of the Dewey Decimal Classification and has been prepared for use in classifying original articles in periodical literature and documents of all kinds. An abridged English edition of the Universal Decimal Classification, comprising an introduction (covering principles and application), main and auxiliary tables and a short alphabetical index, has now been published by the British Standards Institution as B.S. No. 1000A-1948. It is intended for use in libraries in which the detailed subdivision of subjects is not required, or in special libraries using the full classification in a given subject but requiring an abridged classification for other fields. [Price of B.S. No. 1000A 25*s.*, postage included.]

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RECONDITIONING OF THE S.S. "MALOJA."—On June 10, the 21,000-ton twin-screw Peninsular and Oriental S.S. Maloja sailed from Tilbury on her first post-war voyage to Australia as a fully-reconditioned passenger vessel. The work of re-fitting has taken 15 months to complete, and she has been converted to a one-class vessel, now carrying 1,030 tourist-class passengers. The Maloja was built and engined by Messrs. Harland and Wolff Limited, Belfast, and before the war was employed on the Australian route. On the outbreak of war, in 1939, she was commissioned as an armed merchant cruiser, and was employed mainly on North Atlantic convoy work. In 1942 she was transferred to trooping duties. The Maloja will soon be joined on the Australian route by her sister ship, the Mooltan, the reconditioning of which is being completed. She will be ready for service in August.

## BOOKS RECEIVED.

*Electricity Commission. Electricity Supply*, 1944-45. *Return of Engineering and Financial Statistics Relating to Authorised Undertakings in Great Britain for the Year* 1944-45. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 21*s.* net.]

*Ministry of Town and Country Planning. Town and Country Planning (General Development) Order*, 1948. Explanatory Memorandum. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*d.* net.]

*North of Scotland Hydro-Electric Board. Annual Report for* 1947. Offices of the Board, 16, Rothesay-terrace, Edinburgh, 3. [Price 1*s.* 6*d.*]

*A Text Book of Electronics.* By J. M. A. LENIHAN. English Universities Press Limited, St. Paul's House, Warwick-square, London, E.C.4. [Price 12*s.* 6*d.* net.]

*Les Grands Souterrains Transalpins.* By CHARLES ANDREAE. S. A. Leemann Frères et Cie., Stockerstrasse 64, Zürich 2. [Price 22 Swiss francs.]

*Mitteilungen aus dem Institut für Aerodynamik an der Eidgenössischen Technischen Hochschule in Zürich.* No. 14. *Untersuchung von symmetrischen Tragflügelprofilen bei hohen Unterschallgeschwindigkeiten in einem geschlossenen Windkanal.* By DR. SC. TECHN. FRITZ K. FELDMANN. A.-G. Gebr. Leemann & Co., Stockerstrasse 64, Zürich 2. [Price 8 Swiss francs.]

*A Duna-Tisza Csatorna.* By HUGÓ LAMPL and FERENC HALLÓSSY. Bureau of Irrigation, Hungarian Ministry of Agriculture, Mária Valéria-utca 10, Budapest V, Hungary.

*Aeronautical Conference London, 3rd to 5th September*, 1947. *Convened by The Royal Aeronautical Society and The Institute of the Aeronautical Sciences.* Edited by CAPTAIN J. LAURENCE PRITCHARD and MRS. JOAN BRADBROOKE. The Royal Aeronautical Society, 4, Hamilton-place, London, W.1. [Price 2*l.* 12*s.* 6*d.* net to Members; 3*l.* 12*s.* 6*d.* net to others.]

*Technical Optics. A Revised and Enlarged Edition of "An Introduction to Applied Optics.* By PROFESSOR L. C. MARTIN. Volume I. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 40*s.* net.]

*Tait's Electrical Directory of Australia and New Zealand.* Twelfth edition, revised. Tait Publishing Company Pty. Limited, 349, Collins-street, Melbourne, C.I. [Price 21*s.*, post free.]

*The Design of Welded Steel Structures.* By A. RAMSAY MOON. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 18*s.* net.]

*Engineering Drawing for Junior Technical Schools.* By G. B. C. WARD. The English Universities Press Limited, St. Paul's House, Warwick-square, London, E.C.4. [Price 8*s.* 6*d.* net.]

*Fundamentals of Engineering Drawing for Technical Students and Professional Draftsmen.* By PROFESSOR WARREN J. LUZADDER. Revised edition. Prentice-Hall, Incorporated, 70, Fifth-avenue, New York, U.S.A. [Price 2·50 dols.] George Allen and Unwin Limited, Ruskin House, 40, Museum-street, London, W.C.1. [Price 30*s.* net.]

*The Ohio State University. Engineering Experiment Station.* Bulletin No. 131. *Research on Flow Nozzles by the American Society of Mechanical Engineers' Special Research Committee on Fluid Meters.* Prepared under the direction of PROFESSOR S. R. BEITLER and H. S. BEAN. The Director, Engineering Experiment Station, The Ohio State University, Columbus 10, U.S.A. [Price 1 dol., post free.]

*Practical Drawing.* By H. F. TIBRELL. Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 7*s.* 6*d.* net.]

*Model Railways for the Beginner.* Part III. *First Steps in Building to Scale Standards.* By ERNEST F. CARTER. Percival Marshall and Company, Limited, 23, Great Queen-street, Kingsway, London, W.C.2. [Price 3*s.* net.]

*Surveying.* By DR. W. NORMAN THOMAS. Fourth edition. Edward Arnold and Company, 41 and 43, Maddox-street, London, W.1. [Price 30*s.* net.]

*A Glossary of Wood.* By THOMAS CORKHILL. The Nema Press, Limited, 33, Tothill-street, Westminster, London, S.W.1. [Price 21*s.*]

*Teach Yourself Chinese.* By DR. H. R. WILLIAMSON. Published for the English Universities Press Limited, by Hodder and Stoughton, Limited, Warwick-square, London, E.C.4. [Price 7*s.* 6*d.* net.]

*Designing for Mass Production. An Introduction.* By J. R. FAWCETT. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 15*s.* net.]

*Tin Research Institute. The Spectrographic Analysis of Tin and Tin-Lead Solders.* By D. M. SMITH. Offices of the Institute, Fraser-road, Greenford, Middlesex. [Free.]

*The Journal of the Imperial College Chemical Engineering Society.* Volume 3. 1947. Editor: D. I. W. ATKINSON. The Secretary, Chemical Engineering Society, Imperial College, South Kensington, London, S.W.7. [Price 5*s.* 6*d.*, post free.]

## PERSONAL.

GENERAL SIR READE GODWIN-AUSTEN, K.C.S.I., C.B., O.B.E., M.C., chairman of the South-Western Division, National Coal Board, and MR. J. B. DRINNAN, general manager, South Derbyshire area, East Midlands Division, have resigned.

DR. H. ROXBEE COX, D.I.C., B.Sc. (Eng.) (Lond.), M.I.Mech.E., F.R.Ae.S., Director of the National Gas Turbine Establishment, and President of the Royal Aeronautical Society, has been appointed Chief Scientist at the Ministry of Fuel and Power.

SIR ALFRED EGERTON, M.A., F.R.S., F.R.I.C., M.I.Chem.E., Professor of Chemical Technology, Imperial College of Science and Technology, London, and Secretary of the Royal Society since 1938, has accepted the invitation of the Minister of Fuel and Power to be chairman of the Scientific Advisory Council, which will be set up to advise him on the scientific aspect of his statutory duties. The names of the other members of the Council will be announced in the near future.

SIR JOHN KENNEDY, O.B.E., M.I.C.E., M.I.E.E., has agreed to become a member of the Uganda Electricity Board on his retirement from the post of chairman of the Electricity Commission. He will attend to the Board's interests in London and his address will be: East African Office, Grand Buildings, Trafalgar-square, London, W.C.2.

MR. C. J. BARKER and MR. B. THORNTON have been appointed joint managing directors of the Wellman Smith Owen Engineering Corporation, Limited, Parnell House, Wilton-road, London, S.W.1, in succession to the late MR. SYDNEY SMITH.

At a special meeting of the General Committee of Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3, held on June 17, SIR RONALD GARRETT was re-elected chairman for the ensuing year. SIR PHILIP D'AMBRUMENIL was re-elected deputy-chairman and treasurer, and MR. KENNETH R. PELLY, deputy chairman and chairman of the Sub-Committee of Classification. THE RT. HON. LORD ROTHERWICK and MR. R. A. CARDER were re-elected members of the General Committee.

MR. GEORGE A. WILSON, M.Eng. (L'pool), M.I.C.E., who was Superintending Civil Engineer in Ceylon and India for the Civil Engineer in Chief, Admiralty, during the years 1942-45, has been appointed Deputy Chief Engineer to the Port of London Authority from August 1, 1948.

MR. T. W. HAYES, who was assistant Director of Machine Tools, Ministry of Aircraft Production during the recent war, has been appointed export manager of Messrs. A. C. Wickman, Limited, Coventry, under the direction of MR. J. W. BUCHANAN, export director.

MR. NORMAN READMAN, A.C.A., has been appointed deputy managing director of the Consolidated Pneumatic Tool Company, Limited, 232, Dawes-road, London, S.W.6.

MR. I. W. D. MACDOUGALL, D.S.C., at present secretary of Messrs. Mavor and Coulson, Limited, Bridgeton, Glasgow, S.E., has been elected a director of the company.

MR. H. D. B. WOOD, O.B.E., an assistant secretary of the Board of Trade, has been appointed secretary of the South Western Electricity Board, Pulteney Hotel, Bath.

MR. J. L. PACKER has been appointed manager of the Belvedere Works of British Insulated Callender's Cables, Limited, at Erith, Kent, in succession to MR. H. HILL, who retired last month.

MR. SPENCER COPELAND, MR. JOHN COPELAND, and MR. GORDON HEWITT have been appointed to the board of directors of Messrs. W. T. Copeland and Sons, Limited, Stoke-on-Trent, Staffordshire. All three are sons of present directors.

MESSRS. RENDEL, PALMER AND TRITTON are transferring their organisation from 55, Broadway, to more commodious offices at 125, Victoria-street, London, S.W.1. All correspondence posted on or after to-day, June 25, should be sent to the new address. The new telephone number is VICtoria 8494.

THE COAL UTILISATION JOINT COUNCIL have removed their offices to 13, Grosvenor-gardens, London, S.W.1. The new telephone number is VICtoria 1534.

MESSRS. JOHN I. THORNYCROFT AND COMPANY, LIMITED, Thornycroft House, Smith-square, London, S.W.1, announce that, in the interests of efficiency and flexibility, their vehicle-manufacturing business at Basingstoke is to be operated as a separate company. This will be known as TRANSPORT EQUIPMENT (THORNYCROFT), LIMITED, and will be a wholly-owned subsidiary of John I. Thornycroft and Company. The transferred undertaking will become operative as from August 1.

The Convention Offices of the INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION, at Kingsway House, 103, Kingsway, London, W.C.2, have now been closed. Communications regarding the recent Convention should be addressed to MR. J. W. SIMPSON, British Electricity Authority, 16, Stratford-place, London, W.1.

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Scottish Steel.*—Raw materials for smelting charges are being made available to maintain the output of steel ingots at nearly record-breaking levels, but steelmakers are becoming increasingly anxious at the absence of any margin in deliveries for accumulating reserves against the more difficult months ahead. In addition to the shortage of scrap, there is evidence that iron ore supplies are going to be a problem, and there is now some cause for apprehension with regard to scrap and ore supplies. The shortage of iron ore is apparently developing out of the diversion of Swedish and North African ores to Germany to meet the increasing activity in blast-furnace operations there, native ores being uneconomic owing to the large quantities of fuel necessary to smelt them. The output of pig-iron from local blast-furnaces is being maintained at the recent restricted levels imposed by the coke situation.

*Scottish Coal.*—Divisional production has shown little sign of increasing, weekly outputs remaining at some 20,000 tons below the target figures. Absenteeism at week-ends has been high, averaging 20 per cent. on June 12, area figures being 15 per cent. in Central West, 19 per cent. in Fife, 19·6 per cent. in the Lothians, 21·3 per cent. in Central East, and 27 per cent. in Ayrshire. Industrial supplies are coming forward at practically the full programme level. Extra fuel for coke-ovens has been satisfactory, while additional supplies for railways, steelworks, continuous-process users, and bunkers for next month's holiday are expected to be moving shortly. Graded fuel is still below consumers' requirements, and round coal is also rather scarce, although the position is partly alleviated by a reduction in the domestic demand. Export business is steady at about 20,000 tons a week. In addition to Scandinavian and near Continental operators, Spanish and Portuguese importers have been showing more interest, and have purchased a quantity of bituminous duff.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*Iron and Steel.*—Steel production is being steadily increased but supplies are still inadequate, notably in the case of high-carbon basic and acid steels, the shortage of which renders it necessary for some users to make temporary use of steels from the United States and Canada. This is the case in the agricultural-machine parts and edge-tool trades which have been short of suitable types of steel for a long time. Some makers of steel products are compelled to acquire higher grades of steel than are usually employed to make up the deficiency in high-carbon qualities. One of the largest contracts placed for some time with local makers of iron and steel works plant and machinery has been secured by Davy and United Engineering Company, Limited, for the supply to the Steel Company of Wales of continuous plant for the production of steel strip and tin-plate at Abbey Works, Port Talbot. In full production, the plant is designed to have an output of 45,000 tons of steel a week, of which 20,000 tons will be rolled into strip and plate. The Sheffield contract has a value of over 1,000,000*l.* One section is for the construction of a four-high, three-strand tandem cold strip mill, designed for cold-reducing hot-rolled pickled steel strip to be received into the mill in coil form. Another section is for a comprehensive range of plate-finishing equipment. It is designed to deal with 200-ft. length plates between ¼ in. and ⅝ in. in thickness, and 6 ft. in finished width.

*South Yorkshire Coal Trade.*—The production of deep-mined coal is below expectations and short of the growing requirements of industry and the expanding export trade. The railways are requiring full deliveries of locomotive hards for summer train services and for the building up of stocks at the locomotive depots. Full supplies of opencast coal are available but much of it is of poor quality. Coking coal is in stronger demand to meet the heavy calls from coke works which are heavily booked and need fuller production to satisfy industrial demands for coke. Insufficient house coal is reaching merchants to enable them to satisfy current deliveries and to comply with instructions to build up reserves for the winter.

PORTRAIT OF DAME CAROLINE HASLETT.—As a mark of appreciation of the outstanding work of Dame Caroline Haslett in the electrical industry the British Electrical and Allied Manufacturers' Association, the Cable Makers Association and the Electrical Lamp Manufacturers' Association commissioned Sir Gerald Kelly, R.A., to paint the portrait of Dame Caroline which is now on view at the Summer Exhibition of the Royal Academy. We are informed that the portrait is destined to be hung in the Royal Society of Arts, and, at the close of the Royal Academy Exhibition, it will be presented to this Society's Council and will remain as a permanent addition to their collection of portraits.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*General Situation.*—Iron and steel firms are running their plants at very high pressure, but the total tonnage output is insufficient for the unprecedented demands of home and overseas customers. New record makes have been established at the Cleveland works of Messrs. Dorman, Long and Company. The north steel plant has surpassed all earlier weekly outputs with a yield of 7,544 tons, which is 301 tons higher than the previous record achieved at this plant in December, 1939; a basic blast-furnace at the same works has also produced a record weekly tonnage. Steady progress with modernisation of iron and steel plants is reported. All Tees-side products are extensively sold and tonnage allocations over the third quarter of the year are substantial, but buyers hope that further delivery permits will be on a heavy scale. There is a serious deficiency in the supply of scrap suitable for use in the melting furnaces.

*Foundry and Basic Iron.*—The local make of pig iron of the quality required by iron-founders is intermittant and meagre, and there seems to be no likelihood of a resumption of output of No. 3 Cleveland, once so heavily used in the North-Eastern area. The bulk of the foundry iron being used in the Middlesbrough district is from producing areas at a distance. Increasing quantities of basic iron are being sent to the makers' own consuming works, but deliveries do not yet fully meet the demand.

*Hematite, Low-Phosphorus and Refined Iron.*—East Coast hematite firms are dealing fairly satisfactorily with the urgent current needs of their customers, but have no tonnage to spare for other purposes. Regular users are seeking deliveries on a scale that would enable them to replenish their exhausted stocks. Makers of low- and medium-phosphorus grades of iron are meeting the steady demand for those commodities and refined-iron manufacturers can readily dispose of their products.

*Manufactured Iron and Steel.*—Finished-iron production is on a limited scale and the potential output to the end of September is expected to be taken up as soon as it becomes available. Semi-finished steel makers are providing users with more tonnage than has been the case for some time and better supplies of foreign products are reaching the re-rolling mills, but the demand for still larger deliveries of billets, slabs and sheet bars continues. The home industries are securing the greatest benefit of the extra output of finished steel, since present conditions prohibit the full export of commodities. Many home users, however, are having to work on short supplies. The fact is emphasised by an Admiralty intimation that ship repairers must not enter into contracts which involve the use of more steel. The descriptions of material which are in very strong request are sheets, plates, joists, sections, rails and colliery equipment.

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*The Welsh Coal Trade.*—A good level of business was maintained on the Welsh steam-coal market last week and strong conditions were in evidence. Despite the summer falling off in the home domestic demand, a large trade remained to be covered for other users in this direction and a good proportion of the best qualities was engaged here. The large iron and steel works made considerable demands and there were good deliveries to many other industries producing for export. In addition, a large business was met for the essential railway, gas and electricity services. Foreign export activities were quietly maintained but, in this branch, trade was still restricted by the supply position. In nearly all directions buyers showed a keen interest, but there was not enough coal to go round and many inquiries in this branch could not be covered. The largest trade at present is with the Argentine and since releases have been made for Brazil there were indications of more cargoes for this direction. Another market in which there was more activity was Spain. A steady level of deliveries was maintained to France, and Portugal got a fair amount. Supplies for the coaling depots this month have included about 7,500 tons for Casablanca, which was the first for that direction for a long time. Manufacturers of coke were busily engaged and all qualities were fully sold and strong. Patent fuel was in sustained demand and good order lists were held.

*Swansea Steel-Sheet Industry.*—The market report issued by the Incorporated Swansea Exchange states that, last week, tin-plates continued to meet with a brisk demand and numerous orders were placed by home consumers for delivery during the third quarter of the year. There was also a little more activity in the export market, but the sales were not heavy. Steel sheets continue to be sought after, but as makers are already heavily committed, they remain reluctant to accept fresh business. The call for iron and steel scrap shows no sign of diminishing, as the steelworks are absorbing huge quantities in their effort to reach the production target and replenish their low stocks.

## NOTICES OF MEETINGS.

**IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.**

INCORPORATED PLANT ENGINEERS.—*Leeds Branch:* Monday, June 28, 7.30 p.m., Mines Department, The University, Leeds. "Ball and Roller Bearings," by Mr. J. L. Potts. *Birmingham Branch:* Friday, July 2, 7.30 p.m., Imperial Hotel, Birmingham. "High-Frequency Induction Heat Treatment," by Mr. H. Knight. *Newcastle-upon-Tyne Branch:* Thursday, July 8, 7.30 p.m., The Y.M.C.A., Connaught Rooms, Blackett-street, Newcastle-upon-Tyne. "Insulation," by Mr. D. Bryce.

INSTITUTION OF SANITARY ENGINEERS.—Friday, July 2, 6 p.m., Caxton Hall, Victoria-street, Westminster, S.W.1. "The Colne Valley Sewerage Scheme," by Mr. W. Fillingham Brown. Saturday, July 3, 11 a.m. (approximately), morning visit to Colne Valley Sewerage Board's Maple Lodge Works, near Rickmansworth.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Liverpool Branch:* Friday, July 2, 6.30 p.m., 9, The Temple, 24, Dale-street, Liverpool. Joint meeting with the LIVERPOOL ENGINEERING SOCIETY. "The Slide Rule: Its Use and Application for Electrical Engineers," by Mr. G. T. Richards. *York Branch:* Friday, July 2, 7.30 p.m., Royal Station Hotel, York. Discussion on "Members' Experiences."

## CONTRACTS.

The British Electricity Authority, Great Portland-street, London, W.1, announce that, during the past month, contracts have been placed for generating-station, switching and transformer-station and transmission equipment amounting, in the aggregate, to 2,575,505*l.* MESSRS. FERRANTI, LIMITED, have received orders for power transformers for Bankside Generating Station; MESSRS. SIR ROBERT MCALPINE AND SONS (LONDON) LIMITED, a contract for foundations and building works for the extension of the boiler house and turbine house, Stourport generating station; MESSRS. PETER LIND AND COMPANY, LIMITED, orders for civil-engineering and building work, involving a generating station, switch house, coal-handling plant, and foundations to a transformer park at Brunswick Wharf (Poplar) generating station; and MESSRS. THE MITCHELL CONSTRUCTION COMPANY, LIMITED, orders for civil-engineering and building work involving foundations, superstructure, circulating-water system, sidings and other equipment for Peterborough generating station.

MESSRS. DOBSON AND BARLOW, LIMITED, Bolton, Lancashire, have received an order for a complete rayon-spinning plant for installation in China. It is to have a daily capacity of 2½ tons of continuous-filament yarn and will be furnished with Nelson continuous-process spinning and ancillary equipment. This will include preparation and after-treatment machinery and air-conditioning, water-treatment and refrigeration plant. The value of the contract is over 750,000*l.* Delivery is to commence in 15 months and to be completed in 24 months.

FIXING WIRE-ROPE SOCKETS: ERRATUM.—We regret that, in describing a method of fixing wire-rope sockets on page 527, *ante*, we stated that the cone was made of white metal; it is actually made of zinc. Messrs. British Ropes, Limited, Doncaster, who developed the method, also inform us that when the cone has been fixed to the rope, it is advisable to apply "seizings" of wire or strand to the rope close to the small end of the socket, to prevent the latter from becoming loose when the rope slackens.

RECONSTRUCTION OF PLYMOUTH DOCKS.—The damage due to air raids on Plymouth in 1941 reduced the capacity of Millbay Docks for the storage of timber, grain, etc., by about 75 per cent. During the past year, a large area bordering West Hoe-road has been cleared for the storage of imported timber. The remains of eight four-storey houses, and the arches and masonry retaining walls on which they were originally built, have been demolished. About 11,000 cubic yards of material were removed; this included 4,600 cubic yards of solid limestone, which was blasted without interfering with neighbouring houses, permanent way or shipping. A concrete retaining wall, 26 ft. high, with a masonry parapet 4 ft. 6 in. high, has been constructed. The work has been carried out by Messrs. Staverton Builders, Limited, under the supervision of Mr. N. S. Cox, B.Sc., M.I.C.E., divisional engineer, Plymouth, British Railways, Western Region.

# PRE-STRESSED CONCRETE BRIDGE AT FISHTOFT, LINCOLNSHIRE.

(*For Description, see Page* 608.)

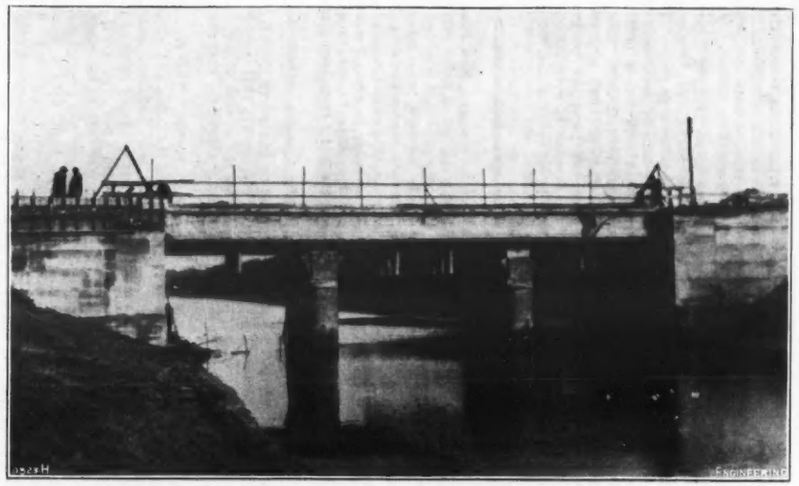

FIG. 10. OLD PIERS SUPPORTING CENTRING FOR NEW BRIDGE.

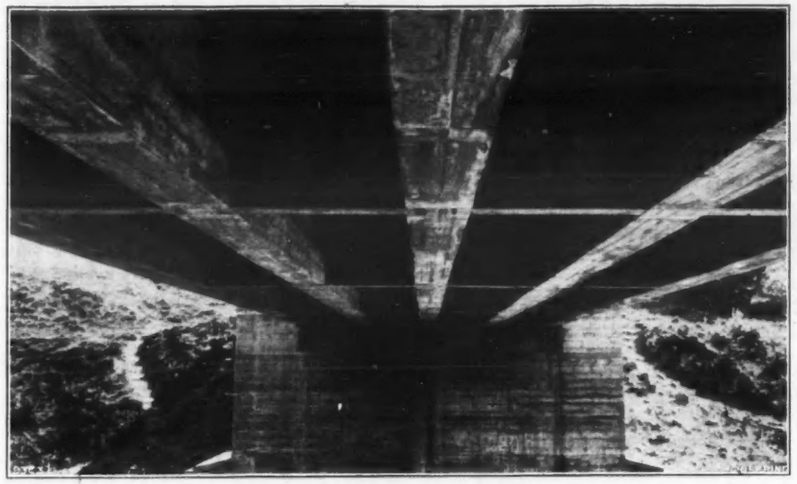

FIG. 11. UNDERSIDE OF NEW BRIDGE.

FIG. 12. PRE-STRESSING CABLES.

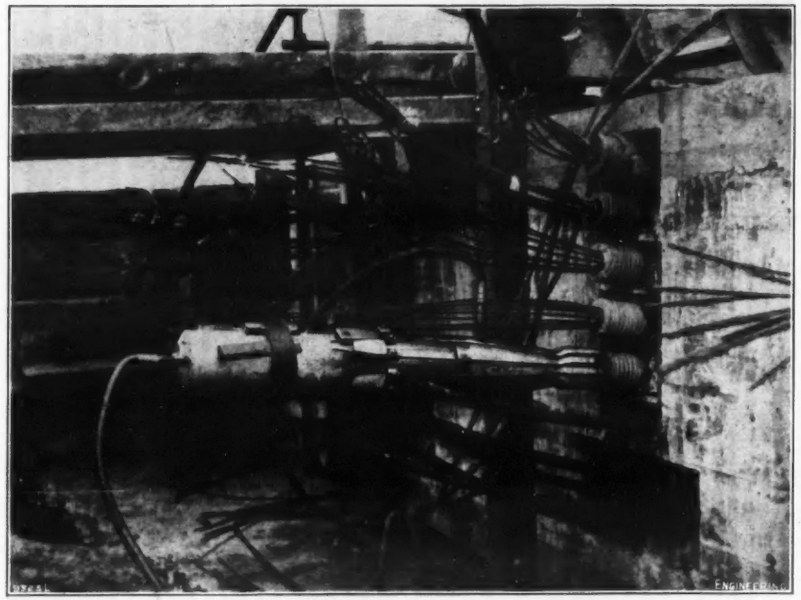

FIG. 13. HYDRAULIC JACK FOR PRE-STRESSING.

# ENGINEERING.

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Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

## TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.


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# ENGINEERING

*FRIDAY, JUNE 25, 1948.*

VOL. 165. No. 4300.


## RAILWAY MOTIVE POWER IN THE FUTURE.

EXTENSIVE experience of the use of Diesel-electric locomotives for fast passenger and heavy freight haulage in the United States has led to an intensive examination of the fundamental problem of railway motive power in that country, in which the possibilities of the gas-turbine locomotive are a prominent feature. It will be remembered that Mr. P. W. Kiefer, of the New York Central System, contributed a valuable analysis of the problem in one of the Centenary Lectures before the Institution of Mechanical Engineers last year; this was based on a more detailed document which has now been published in book form.* There are good reasons for giving great attention to the book in this country, for circumstances here are, perhaps, even more propitious for a general review of the problem of railway motive power. To begin with, nationalisation of the railways is bound to have a marked effect on the trend of development, as did the grouping of the companies in 1924. In addition, the effects of the war have been more drastic in the case of the British railways. This applies particularly to deterioration in the quality of fuel. The railways are not yet entirely out of what has probably been the most difficult period of operation in their history, when chronic loss of time by the locomotives threatened at one period to disrupt the whole organisation of their services. Shortage of locomotive power has been one cause, but the unreliable performance of the steam locomotive with inferior coal has been another, and railway executives are bound to be influenced in the future by their experiences in this respect during the past few years. In the more favourable conditions in the United States, Mr. Kiefer has found it necessary to take into account, in his comparisons of the steam locomotive with other types of motive power, that the former labours under the handicap of occasional low steam pressure and shortage of fuel and water due to poor coal or severe winter weather; and he draws special attention to the progress which is being made in reducing these difficulties and the resulting delays chargeable to the steam locomotive.

These considerations are of great importance because, at its best, the modern steam locomotive can put up a performance quite as good as that of large Diesel-electric units of comparable power, and any marked difference in overall results is likely to depend on the consistency with which a high standard of performance can be maintained. Mr. Kiefer has set out in tabular review the great improvements in steam locomotive design over the past 25 years, and has focussed attention on the improvement of the power-weight ratio, rather than on thermal efficiency. This is in line with the appreciation of locomotive development presented in another paper before the Institution of Mechanical Engineers at one of their ordinary meetings last year, and there is no doubt that the advent of the Diesel locomotive has stimulated the designer of steam locomotives to increase to the greatest possible extent the power which can be obtained within the limitations of weight and space imposed on railway motive power. The engine weight per cylinder horse-power is shown in Mr. Kiefer's table as having been reduced from 103 lb. in 1926 to 71 lb. in 1946, while the speed at which maximum cylinder horse-power is attained has increased from 54 to 85 m.p.h. It is of great interest to note that the Americans contemplate operating their locomotives in regular service at maximum capacity during acceleration from the start, or from enforced slowings, thereafter shortening the cut-off to suit conditions, and they use a device called the "Valve Pilot" to facilitate this. Modern steam locomotives operated in the best conditions have been tried against Diesel-electric engines on the same duties for extended periods, and have not only shown comparable performance but a similar availability ratio, a longer time out of service for shop repairs being balanced by a reduced percentage of time for daily inspection and repair. Experience has shown, however, that, for operation all the year round, steam power falls farther below optimum performance than Diesel power, for the reasons given; and the overall comparison in express passenger service shows potential annual mileages of 324,000 and 288,000 for Diesel and steam; respectively, and percentage availability of 74·2 and 69·0, respectively. In the case of freight service, records of actual usage over extended periods of time showed rather less favourably for the steam locomotive, though the annual potential performance based on a check period of 17 days in favourable conditions gave more equal figures. The dominating effect of the greater variation in the performance of the steam locomotive is also seen in the comparison of annual costs. The total annual cost, inclusive of interest and depreciation, is about 2½ per cent. greater for the Diesel locomotive (two units) than for the comparable 4-8-4 steam locomotive; but, owing to the greater availability of the Diesel, the annual cost per mile is 9 per cent. less. There are no corresponding data yet for the cost of operation of main-line Diesel locomotives in this country, but experience with shunting locomotives is in good accord with the figures given by Mr. Kiefer, and it seems pretty well established that any advantage which the Diesel can hold will depend on its greater availability and more consistent performance.

Some figures for costs are given for electric locomotives, but it is hardly possible to regard the electric locomotive as an alternative form of motive power without widening the basis of comparison to take in the whole economics of electrification—a fact which Mr. Kiefer recognises. Setting electrification aside as a broader problem, attention may be turned to the gas-turbine and steam-turbine locomotives. Mr. Kiefer gives the gas-turbine locomotive great prominence, but in a "practical evaluation of railroad motive power," to quote his title, the gas-turbine locomotive is on a very different footing. So much, indeed, has been written about industrial applications of the gas turbine that even

* *A Practical Evaluation of Railroad Motive Power.* By P. W. Kiefer. Simmonds-Boardman Publishing Company, 30 Church-Street, New York. [Price 2 dols.]

a well-informed engineer might well be forgiven for not realising that, except for a few experimental units, there is as yet practically no operating experience with such a machine. Everything Mr. Kiefer has to say about the gas-turbine locomotive, therefore, is highly speculative, and it would be a serious undervaluation of the comparative data given in the case of reciprocating steam and Diesel locomotives not to emphasise that some parts of the book rest on a much firmer basis of fact than others. As is well known, the Americans have complicated the gas-turbine locomotive problem by proposing to use pulverised coal. From results recently published in this country with an experimental gas-turbine plant, there appears to be some doubt whether the open-cycle gas turbine may not be at least as sensitive to quality of oil fuel as the reciprocating oil engine, at any rate until considerable experience has been gained. This being so, the possibility that the gas-turbine locomotive may share with the steam locomotive the great advantage (to this country especially) of using coal, can hardly be counted in its favour yet. Nevertheless, Mr. Kiefer is in full agreement with those who hold that the gas turbine is peculiarly suited to locomotive propulsion. It affords the possibility of realising the advantages of a turbine drive without the crippling complication of a condenser or the alternative sacrifice of efficiency associated with the non-condensing steam-turbine locomotive. It is expected that three gas-turbine locomotives will be delivered to American railways next year, two using pulverised coal, and one being oil-fired. The results of these experiments may be of great moment to the future of railway motive power, for Mr. Kiefer certainly has full justification, on the basis of every reasonable hope, for placing the gas-turbine locomotive above the Diesel-electric and second only to the all-electric in respect of availability, capacity for work, and overall performance.

Meanwhile, the reciprocating steam locomotive retains the great advantage of being the only proved form of railway motive power burning coal. Its improvement, partly under the stimulation of competition from the Diesel, has been so great in recent years that there is no reason to suppose that its form is yet finalised. It is true that the margin for increased thermal efficiency has shrunk, but there is much that can still be done to raise its power-weight ratio still further, and to overcome its liability to erratic performance. While the railway companies, and particularly the London Midland and Scottish Railway, devoted increasing attention in their last years to research, it cannot escape notice that a relatively small proportion of this had a direct bearing on locomotive design. There has also been a tendency to confuse locomotive testing with research. Admirable facilities for testing are now available, and the data provided by these will aid research, but the field of fundamental research into problems of locomotive design requires much more specific and detailed lines of approach, and is still largely untilled ground. To take one example, little is known about the fundamental action of the blast pipe and smokebox. The functioning of the locomotive is essentially a cyclic action in which steam exhausted from the blast pipe draws air through the firebed and flues and thus produces and transfers the heat necessary for its own generation before expansion in the cylinders. The causes of erratic steaming lie mainly in the conditions controlling this action, and the importance of the front end as the source of the action is obvious. Some very promising small-scale experiments on the locomotive front end, made many years ago at the University of Illinois, still need following up. This would certainly appear to be a suitable moment for opening up an intensive programme of research into such problems of locomotive design. It is not to be denied that many of the detailed improvements adopted in recent years in British locomotive design have originated abroad. Consideration of Mr. Kiefer's survey of the problem of railway motive power suggests that, in the future, this country may be more interested in steam locomotive research than the United States, and it may be confidently expected that this probability will be kept well in mind by those who are now considering the future development of railway research in this country.

## ELECTRICITY SUPPLY IN 1944-45.

THE Electricity Commissioners, or it would be more correct to say the ex-Electricity Commissioners, are gradually catching up with the publication of statistical information, which, for reasons of security, was suspended during the war. It is desirable that this should be so, since it ensures that a record of nearly 30 years will eventually be complete; and will, we hope, check any tendency on the part of the Commission's successors, the Ministry of Fuel and Power and the British Electricity Authority, to be less open in their dealings with the technical public. How useful this information is can easily be ascertained by comparing it with similar data published in other countries. It is accurate, as far as is humanly possible; and what is equally important the successive editions of these sets of statistics are directly and easily comparable.

The particular document to which we refer is the "Returns of Engineering and Financial Statistics relating to authorised Electricity Undertakings in Great Britain." It covers the year 1944–45; and therefore follows fairly closely upon the corresponding document for the preceding year, on which we commented on page 566 of our 164th volume (1947). It contains full operating statistics of the individual local authority and private undertakings (which are tabulated separately), and in each case gives information regarding the system of supply, plant capacity, maximum load, load factor and electricity generated and/or purchased during the year. Financial data, such as capital expenditure and loans raised are also given, while the various items of expenditure chargeable to revenue are set out in detail. All this information is collated in a number of summary tables from which the general position of the public electricity supply of the country during the period under review can be ascertained. In this connection, however, it should be pointed out that these statistics do not tell the whole story. To obtain a complete measure of the extent of electrical development in this country account would also have to be taken of the supplies derived by railway and tramway authorities from their own generating stations; of the output of the large number of private generating stations established by collieries and other industrial and commercial organisations for the purposes of their undertakings (a not inconsiderable addition); and of public supplies given by undertakings operating without statutory powers.

At the end of 1944–45, there were 573 authorised electricity undertakings, including the Central Electricity Board and the North of Scotland Hydro-Electric Board, holding supply powers in the United Kingdom, of which 568 were actually supplying. About 60 per cent. of the generating plant and the same proportion of the output was the responsibility of the local-authority undertakings, the remainder being in the hands of private companies. On the same date there were 362 generating stations, containing in the aggregate 12,177 MW of plant, of which 11,964 MW, or 98·3 per cent. generated alternating current. The 114 largest stations (31·5 per cent. of the total) contained 10,967 MW of plant, or 90·1 per cent. of the total. The electricity generated amounted to 38,245 million kilowatt-hours, compared with 37,790 million kilowatt-hours in 1943–44, an increase of only 1·2 per cent. This last figure clearly indicates that war production during the period was slowing down, as we acquired, in Mr. Churchill's phrase, "all we wanted." It compares with the 6·2 per cent. increase during the previous twelve months, a figure which would probably have been higher if domestic consumption had been restricted to some extent.

Supplies on the alternating-current system were given by 551 out of the 573 undertakings, but direct-current supply was dying hard, as is shown by the fact that the first 229 of these undertakings also operated the latter system. In addition, 15 undertakings supplied direct-current alone. Nearly 10 million of the 10,829,000 consumers however, were supplied with alternating current, the total sales of which were 32,521 million kilowatt-hours; compared with 31,904 million kilowatt-hours in 1943–44, an increase of 1·9 per cent. Of the total sales, 62 per cent. were utilised for power and 34 per cent. for lighting, heating and cooking; the corresponding figures for 1943–44 were 66 and 31 per cent., respectively. Frequency standardisation had resulted in the position that no less than 549 undertakings were supplying at 50 cycles per second. It may be noted, however, as a relic of the past, that two undertakings were still generating at a frequency of 25 cycles per second and the same number at 100 cycles per second, while 30, 80 and 83 cycles per second were each used by one undertaking. The aggregate of the individual maximum loads on the undertakings in 1944–45 was about 11,793 MW; and on the generating stations 10,383 MW. The corresponding figures for 1943–44 were 10,813 MW and 9,968 MW. The load factor was about 42·1 per cent., compared with 43·3 per cent. in the previous year, another indication of the relaxation in the war productive effort.

As regards financial and operating data, the return shows that coal and coke consumption during 1944-45 amounted to 23,399,000 tons (including 4,202,000 tons of pulverised fuel). This figure compares with 22,696,000 tons in 1943-44 (including 3,854,000 tons of pulverised fuel), a difference which was accounted for by the increased output. The average cost, including handling, amounted to 39*s.* 5*d.* per ton, compared with 34*s.* 9*d.* in 1943-44. In addition, 5,613 tons of oil were used for boiler firing and 13,045 tons in oil-engine plant. Nearly 1,300 million cubic feet of gas were also used for boiler firing or in gas engines. The total expenditure charged to capital account at the end of 1944-45 was 775,401,000*l.*, compared with 763,195,000*l.* at the end of the previous twelve months, the net capital expenditure in the two years being 12,206,000*l.* and 16,737,000*l.*, respectively.

The total revenue of all the authorised undertakings was 151,946,000*l.*, compared with 142,182,000*l.* in 1943-44. This represented an average of 1·121*d.* per kilowatt-hour sold, compared with 1·069*d.* in the previous year. For lighting, heating and cooking the average revenue was 1·558*d.*, compared with 1·627*d.* in 1943-44, although an examination of the complete tables shows considerable variations in this respect between the individual undertakings. For power supplies, the average revenue per kilowatt-hour was 0·804*d.* compared with 0·737*d.* in 1943-44. The total working expenses amounted to 94,778,000*l.* and absorbed 62·4 per cent. of the revenue, compared with 60·9 per cent. in 1943-44. Of the total working expenses, generation accounted for 58 per cent., compared with 55 per cent. a year earlier, the average working expenses per 100*l.* of capital expenditure being 12·2*l.*, compared with 11·4*l.* in 1943-44. The number of staff and workmen in regular employment in the industry at the end of 1944-45 in operating and maintaining the undertakings of the electricity supply industry was 89,663, compared with 88,988 at the end of 1943-44. Of these, 53,238 were employed by local-authority undertakings and 34,593 by private companies, the remaining 1,832 being in the service of the Central Electricity Board. As roughly 56 per cent. and 44 per cent. of the output was in the hands of public authorities and private companies, respectively, it would appear that the latter were able to carry on their business with rather less staff than the former, and therefore more efficiently at a time when it was desirable that individual outputs should be increased. This is a tendency which will need watching in future, as there is already some indication that the British Electricity Authority is not wholly resisting the temptation to centralise. While the return is mainly of historic interest, it is none the less valuable for that. It will no doubt be followed in due course by others giving information about operations up to March 31, 1948, on which date the Electricity Commission ceased to exist. We hope in bringing their useful work to a close this body may find it possible, paper restrictions permitting, to issue a summary of the progress made for the whole period during which they have been responsible for the fortunes of the industry.

* *Electricity Commission. Electricity Supply* 1944-45. London: H.M. Stationery Office. [Price 1*l.* 1*s.* net.]

# NOTES.

### SCIENTIFIC INFORMATION CONFERENCE.

ON Monday last, the President of the Royal Society, Sir Robert Robinson, opened a Conference on the Distribution of Scientific Information, organised by the Royal Society and held at Royal Institution, Albemarle-street, London, W.1. He informed the audience of 500 scientists that the conference was the outcome of a request made at the 1946 Royal Society Empire Scientific Conference and by the British Commonwealth Scientific Official Conference held in the same year. Sir Edward Appleton, F.R.S., and Sir Henry Tizard, F.R.S., also addressed the conference at the opening session. As indicated in the programme, which we published in our issue of June 11, on page 572, its purpose is to discuss and recommend to the Council of the Royal Society any ways in which the present systems of publishing original scientific work, the abstracting of it and the indexing of it for future reference can be improved. The conference will concern itself only with scientific information services in the English language. It will continue in session until Friday, July 2. That such a gathering may prove profitable is shown by the fact that about 750,000 useful scientific papers are published each year in 15,000 periodicals. That it may have its dangers is indicated by a proposal of Professor J. D. Bernal that authors should send their manuscripts to a National Distributing Authority; and that this body after due examination would forward them to the journal most likely to be interested. Such a proposal is hardly likely to win the acceptance of either authors or editors. The latter, in particular, will argue that they would prefer to make their own choice, even if that means more work; while the former will, we think, prefer to be judged by independent individuals. During the meeting a number of visits are taking place to libraries, laboratories and printing works, so that delegates can examine the processes connected with one or more aspects of the distribution of scientific information. An exhibition with the same end in view has also been arranged at Burlington House. This includes demonstrations of printing and other reproduction processes, classification methods, microfilm apparatus and examples of publications.

### ROAD FERRIES.

The Minister of Transport set up a committee in May, 1946 "to investigate ferry services linking trunk and classified roads, and to make recommendations for the improvement of their equipment and operation." The report of the committee has now been published. It makes various detailed recommendations bearing on the improvement of some existing ferries both in connection with landing and shipping arrangements for vehicles and, in some cases, for the provision of larger vessels. The most important recommendation made, however, is that "ferries generally should be freed from toll." It is stated that, although a ferry is comparable with a public passenger or goods vehicle, it should nevertheless be generally regarded as a substitute for a bridge or tunnel, until such time as a permanent crossing may be justified. To enable this policy of free ferries to be put into operation, it is proposed that highway authorities should be empowered to take over, compulsorily if need be, ferries linking trunk or classified roads. The expenses incurred in the acquisition, improvement, maintenance and operation of the ferries should be met in part by Government grants. In the case of the Highlands and Islands of Scotland, it is suggested that the grants should be on a one-hundred per cent. basis. The committee is not entirely consistent in its contention that ferries should be freed from toll and states that "where major improvements are required and highway authorities find their share of the cost is too heavy, a limited concession may prove necessary, similar to that made in the Forth Bridge Confirmation Act, 1947, which allows the imposition of tolls for a maximum period of 30 years." The general proposition that a ferry on a trunk road is part of the road, and should be as free from toll as the remainder, is logical, but that is not to say that further light-hearted demands for Government grants are justified. In the present financial position of the country and the scale of taxation ruling, continued demands on "central funds" (the expression used in the report) are becoming a menace to the restoration of prosperity. There are no "central funds" in any proper sense and if ferry users are to be subsidised at the public expense, the cost, however it may be disguised, must come from increased taxation. There is no noticeable general demand for the elimination of ferry tolls and in present circumstances the transfer of the costs which they represent from the ferry user to the general public is economically undesirable. The proposal that, when improvement charges are heavy, tolls may still be levied is illogical. Where such charges are heavy it may be assumed that the ferry forms an important link (if it does not, heavy charges are not justified), and the importance of the traffic concerned might be adduced as a reason for it to be freed, partly from the point of view of eliminating delay; where the ferry is of less importance, costs may be less, but that is not in itself a reason why they should be met by general taxation.

### THE BRITISH INTERNAL-COMBUSTION ENGINE RESEARCH ASSOCIATION.

The British Internal-Combustion Engine Research Association celebrated the fifth anniversary of its inaugural meeting by holding a luncheon at Claridge's Hotel, London, on Wednesday, June 16, the President, the Rt. Hon. The Viscount Falmouth, being in the chain. The toast of "The Association" was proposed by the Rt. Hon. G. R. Strauss, M.P., Minister of Supply, who, after referring to the important work carried out by the Association, congratulated the Diesel-engine industry on their performance in the export drive, as much as 90 per cent. of their total output having been exported. The seller's market, however, was disappearing and in the future our engines must not only look well but give a good performance. This entailed expansion of our research facilities; even though research was more active and widespread in this country than ever before, it must expand further and he pledged the support of the Government in this, stating that there would be no cuts in expenditure on this important item. The response was made by the Chairman who, in thanking the Minister of Supply for his speech, mentioned the great help rendered the Association by his Ministry. The Chairman then made reference to the use of the term "Diesel" engine; this, unfortunately, had become widespread but it was a misnomer and in his opinion the name "high-compression" engine should be used. Turning to the present day, he felt that although imported fuel was used, there was a great future for the Diesel engine which, taking the analogy of the steam engine, had passed the Watt stage and was now in the Trevithick stage. The Diesel-engine industry was built up on research which, so far as they were concerned, was not an expensive luxury but essential to their well being. The toast of "The Guests," was proposed by Mr. O. Wans, who referred to the brilliant record of Sir Edward Appleton, G.B.E., K.C.B., and the happy relations of the Association with his department. In his reply, Sir Edward, after thanking Mr. Wans for his remarks, said that research must go on, and he felt sure that still new things would be discovered in the field of prime movers.

### ELECTRICITY SUPPLY IN THE NORTH OF SCOTLAND.

Particulars regarding the Lawers project (Constructional Scheme No. 18) were issued by the North of Scotland Hydro-Electric Board on Tuesday, June 22. This scheme will utilise an area, including Ben Lawers and the adjacent mountains in Perthshire, which, owing to its high altitude and excessive rainfall, will enable 71,000,000 kWh to be produced in a year of average rainfall. This output will be employed towards meeting the local requirements for electricity; and towards supplementing supplies both in the southern part of the Board's area and in Central Scotland generally. For this purpose it is proposed to tap the waters of various streams draining the slopes of Ben Lawers and lead them to a reservoir which will be formed by enlarging Lochan na Lairige on the pass between Killin and Glen Lyon. Most of this collection will be done at altitudes exceeding 1,720 ft. above sea level. The reservoir will be constructed by building a dam 1,250 ft. long and 130 ft. high across Allt A'Mhoirneas, about 470 yards from the outlet of Lochan na Lairige, which will impound 2,900 million gallons of water and provide a usable fall to Loch Tay of 1,362 ft. The impounded water will be led through a pressure tunnel and pipeline to a power station with a capacity of 30 MW, which is to be built near Finlarig, at the Killin end of Loch Tay. This station will form one of a group of five, which will be remotely controlled from Killin.

### INTERNATIONAL INSTITUTE OF WELDING.

At a meeting attended by representatives of 14 countries, held in Brussels during the second week of June, the International Institute of Welding was formed. The primary business of the meeting was to establish the foundations of the Institute and to set up a number of special commissions on various technical subjects. In addition, two sessions were devoted to technical papers, each of which reviewed the existing knowledge in a given field of study and formulated suggestions for further research. One of these papers, on "The Present Position with regard to Residual Stresses," was contributed by Dr. R. Weck, of the British Welding Research Association. Other papers were presented by Mr. W. Bonhomme, Mr. W. Soete and Professor G. Homès, of Belgium; Mr. C. G. Keel, of Switzerland; Professor A. Portevin, of France; and Professor F. K. Th. van Iterson, of the Netherlands. It is intended that an annual meeting of similar character shall be organised in the future, and the Governing Council of the Institute have accepted an invitation from the Netherlands to meet there in 1949. They have also accepted an invitation from the British delegation to hold the first World Welding Congress in Great Britain in the British festival year, 1951. In connection with the new Institute, a special compliment has been paid to the welding community in the United Kingdom, through the election, as the first secretary general, of Mr. E. Parsloe, the secretary of the Institute of Welding, 2, Buckingham Palace-gardens, Buckingham Palace-road, London, S.W.1.

### CENTENARY OF WATERLOO STATION.

Owing to the extensive railway developments being undertaken about a century ago, it falls to the lot of this generation to observe the centenaries of the openings of many railway lines, stations and works. That of Waterloo Station, which occurs this year, will interest a large number of people because of their associations with the station; emigrants, soldiers, and civilians on business and holiday, remember Waterloo, and many will recall the reconstruction of the station and its opening by H.M. Queen Mary on March 21, 1922. A small exhibition to illustrate the history of Waterloo closes to-day, Friday, after having been kept open for an extra week due to public interest. It was opened on Monday, June 14, by Sir Herbert Walker, K.C.B., who was general manager of the London and South Western and Southern Railways from 1912 to 1937. After the opening ceremony, and on Wednesday, June 23, two old locomotives and one new engine were exhibited in steam at No. 15 platform. They were an Adams 4-4-0 locomotive, No. 563, of the former L.S.W.R., built at Nine Elms Works in 1893; "Boxhill," an 0-6-0 "Terrier" tank engine built by the London Brighton and South Coast Railway in 1880; and a "West Country" class engine on the opening day, and a "Battle of Britain" class engine on Wednesday last. The original Waterloo Station was built on an open site formerly occupied by farmyards and cow sheds. It was extended in the sixties, seventies, and eighties of last century, and is now the largest passenger station in Great Britain. It covers an area of 24½ acres, has 21 platforms, and 200,000 passengers pass through it every 24 hours. The exhibition contained a number of interesting old prints and photographs. Two of the few surviving relics of the old station are the toll house, near Griffin-street, and the station bell.

## LETTER TO THE EDITOR.

### WARSHIPS AND UNDERWATER EXPLOSIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—In your editorial of May 28, page 517, on my paper "The Effect of Non-Contact Explosions on Warship Machinery Design," you point out that the final effect of the propagation of stress waves is clearly the damage to the machinery. With this I quite agree, the object of my remarks on waves of stress being to discount the hammer-blow theory, namely, that from the initial compression wave a direct tensile reflection was formed sufficient to cause fracture, as in the case of the red-short iron bar. This, of course, is possible with brittle materials of suitable shape, but these have not been normally met with, and fracture is generally the result of the longer term build-up of a stress of appreciable duration. I trust that this enlargement on my somewhat ambiguous sentence will absolve "Hamlet's father's ghost" from materialising at future underwater explosions.

Yours faithfully,
A. D. BONNY,
Commander (E), R.N.
Admiralty Machinery Dept.,
Wellfield Works,
Llanelly,
South Wales.
June 11, 1948.

[We are afraid that Hamlet's father's ghost, in other words, destructive stresses of very short duration, will always attend explosions and impacts. Even in pile driving, the lower end of a concrete pile may be broken off by a wave of stress reflected from the foot when it passes through a cavity in the ground.—ED. E.]

## OBITUARY.

### SIR D'ARCY THOMPSON, C.B., F.R.S.

BY the death of Sir D'Arcy Thompson, which occurred on June 21, at St. Andrews, Fife, a venerable and highly respected figure has passed from Scottish scientific circles. D'Arcy Wentworth Thompson, who was Professor of Natural History at St. Andrews University for many years, was born in 1860, and was the son of a classics master of the same name, then teaching at Edinburgh Academy. He received his general education at this institution and then took up the study of medicine at the University of Edinburgh. He had not proceeded very far with his course, however, when he won a scholarship tenable at Trinity College, Cambridge, where he studied zoology and physiology. In 1884, at the early age of 24, he returned to Scotland to take up the appointment of Professor of Natural History in University College, Dundee. The College was founded in 1880 and was affiliated to, and made to form an integral part of, the University of St. Andrews in 1897. In 1917, D'Arcy Thompson was appointed Professor of Natural History in St. Andrews and continued to serve in this capacity for the remainder of his life. He was elected a Fellow of the Royal Society many years ago, was made a Companion of the Order of the Bath in 1898 and created a Knight in 1937.

Sir D'Arcy wrote and lectured on a wide variety of subjects with many of which engineers, in general, are not concerned. His scholarly work *On Growth and Form*, which was first published in 1917 and re-issued in revised and enlarged form in 1942, however, is in a class by itself. In a review of the book, published in ENGINEERING, vol. 155, page 202 (1943), we pointed out that the work confined its attention to that branch of biology known as morphology, the science of the forms of organisms, and that the author demonstrated that these bodies are subject to the laws of physics and mechanics as much as are the structures of the engineer. Thus, in his chapter entitled "On Form and Mechanical Efficiency," Sir D'Arcy analysed animal and plant structures in terms of mechanical constructions and much of what he has to say is not only of interest to physicists and engineers but contains suggestions which might prove useful in their work.

## INSTITUTION OF MECHANICAL ENGINEERS; SUMMER MEETING.

THE Glasgow Summer Meeting of the Institution of Mechanical Engineers, which was attended by 433 members and 231 ladies, was favoured by good weather and was concluded on Thursday, June 17. It was the first post-war summer meeting, although a meeting was held in the summer last year in connection with the centenary of the Institution. This year, the Institution entered on its second century by visiting the city which, in 1856, first entertained it at a summer meeting.

As recorded on page 591 of our issue of last week, the meeting opened on Tuesday morning, June 15, in the Royal Technical College. After the Lord Provost of Glasgow, Sir Hector McNeill, F.E.I.S., had welcomed the President, the Council and members of the Institution and their ladies, and Major William Gregson, M.Sc., had expressed thanks, most of the members attended the reading and discussion of the paper on "Some Recent Advances in Mechanical Engineering on Shipboard," by Mr. T. A. Crowe, M.Sc. In the afternoon, the members divided into parties to visit engineering establishments. One party was shown around the works of Messrs. Babcock and Wilcox, Limited, Renfrew, who make all kinds of auxiliary equipment for the generation of steam, mechanical-handling plant and pressure vessels, in addition to their well-known boilers. Messrs. Harland and Wolff, Limited, entertained a party at their works at Finnieston, where Diesel engines are built for marine and industrial purposes. Messrs. John Lang and Sons, Limited, also entertained a party at their works at Johnstone.

Another party visited two works, both in Scotland-street—those of the Mirrlees Watson Company, Limited, and Messrs. James Howden and Company, Limited. The former firm manufacture a wide variety of engineering equipment at several works, and the products of the works visited include sugar machinery, condensing plant, etc. Messrs. James Howden and Company, Limited, manufacture heavy-duty forced- and induced-draught fans, auxiliary steam engines and turbines, air pre-heaters, dust-collecting equipment, gas-washing plant, compressors, etc. Other parties visited the Atlas and Hydepark works at Springburn and the Queen's Park works at Polmadie of the North British Locomotive Company, Limited; and the works of Messrs. G. and J. Weir, Limited, Cathcart, manufacturers of boiler feed pumps, heat-exchange plants, air compressors, refrigerating plants, etc.

As already recorded, the Lord Provost and Magistrates held a reception on Tuesday evening in the City Chambers. On Wednesday morning, the Automobile Division, with the Chairman, Captain G. T. Smith-Clarke, M.I.Mech.E., in the chair, held a meeting in the Royal Technical College, at which Mr. H. W. Fulton, B.Sc., presented his paper on "Export Vehicle Design." On page 607 of this issue we conclude reprinting this paper, which deals with a matter of great importance to the automobile industry, and which evoked an interesting discussion at the meeting. In the afternoon, those members who had attended the morning meeting visited the works of Messrs. Albion Motors, Limited, under the guidance of Mr. Fulton, who is the managing director. On the same day, other members divided into several parties and visited other works in the morning and afternoon. One party was shown round the works of Messrs. Babcock & Wilcox, Limited, to which we have already referred, and in the afternoon visited one of three works: Messrs. J. and P. Coates, Limited, Paisley, manufacturers of threads for sewing, embroidery, etc.; Messrs. L. Sterne and Company, Limited, who, at their Hillington works, manufacture refrigerating machines of the smaller sizes; and Messrs. James Templeton and Company, Limited, manufacturers of carpets.

Another party on Wednesday visited the Rutherglen works of British Ropes, Limited, where the wire, drawn at the firm's mills in England, is stranded and closed round a hemp core to form a wire rope. In the afternoon, the party was shown round the works of Messrs. Hoover (Electric Motors), Limited, at Cambuslang, where fractional-horse-power motors are produced. A large number of members and ladies spent Wednesday morning at the Clydebank engineering and shipbuilding yard of Messrs. John Brown and Company, Limited. They were shown over two vessels, including the Caronia, which will be completed shortly and which Mr. Crowe described in his paper the previous day. They also saw a 500-h.p. open-cycle gas turbine in operation, which the firm have built to the design of the Parsons and Marine Engineering Turbine Research and Development Association (Pametrada), for experimental work. It uses oil fuel and is at present coupled to a compressor which supplies compressed air to the works mains. In the afternoon, the members visited either the works of the Singer Manufacturing Company, Limited, which are engaged in the production of the well-known sewing machines, or the biscuit factory of the United Co-operative Baking Society, Limited, both at Clydebank.

Visits were also paid on Wednesday either to the Clyde Iron Works, Tollcross, or the Clydebridge Steel Works, Cambuslang, both of Messrs. Colvilles, Limited. The Clyde Iron Works dates back to the Napoleonic Wars, and the Clydebridge Steel Works was opened in 1888. In the afternoon, both parties visited the same firm's Dalzell Steel Works at Motherwell. On the same day, other parties visited the Motherwell works of the Clyde Alloy Steel Company, Limited; the Lanarkshire Steel Company, Limited, Flemington, Motherwell; Messrs. Anderson, Boyes and Company, Limited, Motherwell, who construct colliery machinery; the Fairfield Shipbuilding and Engineering Company, Limited, Govan; Messrs. Alexander Stephen and Sons, Limited, Linthouse, shipbuilders and repairers; Messrs. British Polar Engines, Limited, Govan, makers of Diesel engines; Messrs. Thermotank, Limited, Govan, makers of air-conditioning and ventilating equipment; Messrs. David Rowan and Company, Limited, marine engineers and boiler-makers; and the engineering and physics laboratories of Glasgow University.

On Wednesday evening, a dinner was held in the Grosvenor Restaurant, Glasgow, with the President, Major William Gregson, M.Sc., in the chair. The toast of "The City and Industries of Glasgow" was proposed by Lord Dudley Gordon, D.S.O., immediate past-president. He compared the growth of the city during the past 100 years with the growth of the Institution. Bailie John M. Inglis, who responded to the toast, spoke of the part engineers had played in the development of Glasgow. Sir James Lithgow, Bt., G.B.E., C.B., M.C., chairman of the Glasgow Reception Committee, who also replied, said that when the present generation woke up to the necessity for work, the nation would go "from strength to strength." The President proposed the toast of "The Guests," and warmly thanked the many persons who had contributed towards the success of the Summer Meeting. The response was made by Sir Hector Hetherington, M.A., LL.D., D.Litt, Principal and Vice-Chancellor of the University of Glasgow, who expounded the social significance of science. It was quite vain, he said, to wish that the inmost secrets of nature had not been revealed by science. It was in no man's power to stop the advance, and yet, paradoxically, the advance could not continue without the co-operation of engineers and scientists. The moral and political problems were vital, and he appealed to all concerned with the teaching and the minds of young people to keep these great issues before them. The dinner terminated with the President proposing the toast of "The Institution."

On Thursday, the last day of the meeting, visits were paid to works in the Greenock and Kilmarnock areas, and an excursion was made by motor coach to Tarbet, Loch Sloy, where the party inspected the power station, and to Drymen. The meeting terminated in the evening with a Conversazione at the Royal Technical College, given by the Scottish Branch Committee. The guests were received by Mr. A. D. Edmond, chairman of the Scottish Branch, and Sir James Lithgow, and they were invited to inspect some of the departments of the College. In the department of natural philosophy, an interesting apparatus for demonstrating the phenomenon of cavitation was shown.

# THE WORK OF THE NATIONAL PHYSICAL LABORATORY.

AN exhibition of the work being carried on at the National Physical Laboratory, Teddington, was held on Monday and Tuesday, June 21 and 22, the former being an "Open Day," to which representatives of industrial organisations were invited. For the first time, invitations were also issued to representatives of industrial firms between whom and the Laboratory contact had not previously existed. Another innovation was that visitors were invited to fill in a form stating whether there was any investigation of immediate importance to their industry or organisation which it was felt the Laboratory could undertake. On the second day the Laboratory was inspected by the General Board, of which the President of the Royal Society (Sir Robert Robinson) is chairman; and was visited by members of university staffs and Government departments.

There were no less than 272 exhibits on view displaying great variety in objective, dimensions, and complication. Among these mention may be made of the tidal model of the estuary of the River Wyre in Lancashire, which has been constructed in order that the means of stabilising the course of the low-water channel in the estuary may be studied. This model was on a horizontal scale of 1 in 1,000 and occupies a space of about 60 ft. by 15 ft. The river bed is reproduced in fine sand with a vertical exaggeration of the depths and slopes of 10 to 1. The tide, which in nature has a range of about 30 ft., is reproduced in the model by a periodic displacement of 3·6 in. in the level of the water at the seaward end. This displacement is effected by raising or lowering a 2-ton plunger by a hydraulic jack, the latter being controlled by a system of cams through hydraulic servo-mechanism. In this way variations in tidal range over a fortnightly cycle of springs and neaps can be reproduced. As a "tide" occurs in the model every seven minutes, a week's continuous running represents one year in nature. It should be added that since October, 1947, the responsibility for the work on tidal models has been taken over by Sir Claude Inglis, Director of Hydraulics Research.

The work in the Ship Division of the Laboratory continues to be mainly directed towards providing for the immediate requirements of the industry, such as are arising from the large volume of new construction which is now in hand for both British and foreign owners. The larger of the tanks has been equipped with a wave-maker of the plunger type, thus enabling researches to be carried out on the resistance and propulsion of ships in rough water. The vibration of ships' hulls is another subject upon which full-scale research is being undertaken in this Division, special attention being paid to vessels of the passenger-liner class. Demonstrations were given of a propeller working under cavitation conditions in the Lithgow water tunnel. To study this phenomenon it is necessary to scale down the pressure as well as the size of the propeller; and this cannot be done in an open tank. The propeller under examination is flash-lighted; and this lighting is synchronised with the blade rotation to enable the cavitation to be inspected. Arrangements are also made for measuring the propeller thrust and shaft horse-power.

Among the numerous exhibits in the Aerodynamics Division mention may be made of an apparatus for measuring the air forces on oscillating aerofoils in use on a swept-back wing. A knowledge of these forces is required for the prediction of critical flutter speeds and their measurements on models in a wind tunnel is valuable as a check on theory, particularly in such cases as vibrations about large mean incidences. In the apparatus exhibited, a large mechanical oscillator is situated beneath the working section of a wind tunnel; and imparts a sinusoidal motion to the model through a rigid linkage system, which is connected to a special balance. A mass and spring, which are incorporated in the linkage system, automatically cancel out any inertia and spring forces present, so that the reaction at the balance is due to the aerodynamic forces alone. The balance was developed specially to give good frequency response and small phase shift. In its design, use is made of the change that occurs in the length of a steel strip when loaded. These changes, in turn, alter the width of a slit on which the image of a lamp filament is focused and from which it emerges to fall on a photo-cell. The output from this cell is compared in an alternating current bridge with reference voltages, the latter being obtained from coils which are driven by the mechanism operating the model. This equipment is at present being used to determine the effect of sweep-back on the oscillatory forces which occur on a rigid wing while it is performing a rolling oscillation about the root chord as axis.

A xylonite elastic wing for investigating aileron reversal was also exhibited by the same Division. This model wing, which reproduces the major structural characteristics of a typical aeroplane wing in miniature, is mounted in the wind tunnel, so that it is free to rotate about a longitudinal axis. The rates of rotation at various wind speeds and aileron angles are then measured, and the results obtained for any forward speed are compared with those given by calculation. The consequent data enable wings to be designed so that they are sufficiently stiff to cause no serious loss of rolling power in the flying speed range.

An investigation which is now being carried out in the Engineering Division of the Laboratory is concerned with the high-speed ball and roller bearings for use in gas turbines. For this purpose, several machines capable of running at speeds up to 30,000 r.p.m. have been designed, one of which is provided with an electronic circuit, so that it is stopped when an increase in the frictional force above a critical level indicates that seizure of the bearing is imminent. This is effected by arranging for small variations in the strain on a weighbar to be converted into voltage changes by an electrical resistance strain gauge circuit. When the strain exceeds this pre-determined value, an electronic trigger is tripped, thus stopping the machine before serious damage occurs. The fundamental principles underlying the operation of Michell and plain thrust bearings running under fluid-film conditions are also being investigated, with the object of ascertaining whether those bearings can be used to replace ball bearings under these conditions. For this purpose, a Michell bearing with an external diameter of 9 in. is run at a speed of 10,000 r.p.m. under a thrust load of 10,000 lb. Air-gauging methods are used to measure variations in oil-film thickness. Nozzles are mounted on this bearing within a few thousandths of an inch of a rotating reference ring on the shaft. Any movement of the bearing, due to changes in the thickness of the oil film, then alters the distance between the nozzle orifice and this ring, the result being that the back pressure set up in the air-feed pipe is altered. This alteration is indicated on a pressure gauge and is a measure of the variation in the thickness of the oil film. An interesting outcome of this work is that it indicates the possibility of using the oil film pressures which arise from centrifugal action to increase the carrying capacity of the bearing. In this connection it may also be noted that the study of the lubrication of machine components, in which the motion is discontinuous, has been greatly assisted by the use of electrical strain gauges and cathode-ray oscillographs. The employment of this apparatus enables continuous records of frictional forces to be obtained, as is shown when the method is applied to oscillating journal bearings and reciprocating slides.

The increase in the work of the Laboratory naturally demands the periodical installation of new apparatus. In the Electricity Division, for instance, the equipment has been augmented by a vacuum-impregnating plant. This has been provided by the British Electrical and Allied Industries Research Association for drying and impregnating material which is to be treated to breakdown under surge voltages. With this equipment, a vacuum of 0·01 mm. of mercury can be obtained on the dry impregnator and it is being regularly used for the investigation of breakdown by puncture or flashover of pressboard sheets and tubes in transformer oil. Another interesting apparatus in the Division is a sealed-off cathode-ray oscillograph, which is being employed for recording most transients without recourse to special photographic techniques. It has the further advantages of compactness and lightness while its deflection sensitivity is high, the trace can be observed while it is being recorded, the films and plates can easily be changed, and there are, of course, no vacuum troubles. It is therefore, considered that it compares favourably with the more usual continuously-evacuated oscillograph which, besides being expensive, requires skilled operators to use it.

The exhibits in this Division included an equipment for extending the range of quartz-controlled oscillations to centimetric wavelengths. In this apparatus, sources of oscillation with a power of about 3 watts are obtained by the use of a number of stages of frequency multiplication, mixing and amplification. These sources have frequencies, which are controlled by the primary standard, of 33·6 to 36·8 megacycles per second in steps of 0·4 megacycles per second; of 67·2 to 73·6 megacycles per second in steps of 0·8 megacycles per second; and of 201·6 to 220·8 megacycles per second in steps of 2·4 megacycles per second. By using these oscillations and their harmonics, as many as 36 controlled frequencies can be obtained in the 350 to 8,000 megacycles per second range at intervals of about 1 per cent. A variable frequency oscillator, monitored by the standard, is used to interpolate between the controlled frequencies without much loss of accuracy. Two further stages are being added to extend the range to 50,000 megacycles per second. A demonstration of the application of this equipment to the calibration of a wavemeter in the region of 3,000 megacycles per second was given. The sources at their fundamental frequencies can also be employed for testing cables and dielectrics, as well as for the study of the radio frequency spectra of atoms and molecules. For instance, the ammonia molecule has been found in this way to have lines in the neighbourhood of 23,000 megacycles per second and the frequencies of these lines have been measured to an accuracy of 1 part in 1,000,000. As such lines can be used as standards of frequency, it is not surprising that the possibility of obtaining molecular standards of this kind is exciting considerable scientific interest.

A machine made in the Metrology Division, and shown during the inspection, has been designed for measuring the diameter and rate of taper of tapered plug screw gauges. It will accommodate gauges up to 24 in. in diameter, such as the reference master gauges mentioned in the specifications issued by the American Petroleum Institute. The gauge to be measured is mounted on a horizontal turntable, the height of which can be adjusted. Diametrical measurements are made with a floating micrometer with a fiducial pressure indicator, which is mounted in a headstock. This headstock is attached, with the tailstock, to a slide, which runs on steel balls laid in grooves in the main casting. An important feature of the machine is that the sensitivity of the measuring micrometer is independent of the weight of the gauge under test. The mounting of both the micrometer and fiducial pressure indicator in the headstock also facilitates the measurement of large gauges. Reduction gearing is provided so that heavy gauges can easily be raised or lowered; and diametrical observations along their length is thus rendered easier.

One of the interesting activities in the Metallurgy Division is the preparation of new materials and the study of their properties. In this connection mention may be made of the fact that vanadium and titanium are now being prepared in a high state of purity. Experiments on the production of vanadium by the reduction of the pentoxide by metallic calcium in a steel bomb at a temperature of 850 deg. C. have, in fact, yielded a product consisting of small beads of fairly pure metal and a larger quantity of fine powder. The oxygen content of this powder is, however, higher than is desirable. Attempts are therefore being made to reduce it. The production of both vanadium and titanium by the hydrogen reduction of vanadium pentoxide and titanium chloride has also been put in hand.

# PASSENGER STEAMER "COMMANDANT QUERÉ."

MESSRS. JOHN I. THORNYCROFT AND COMPANY, LIMITED, LONDON.

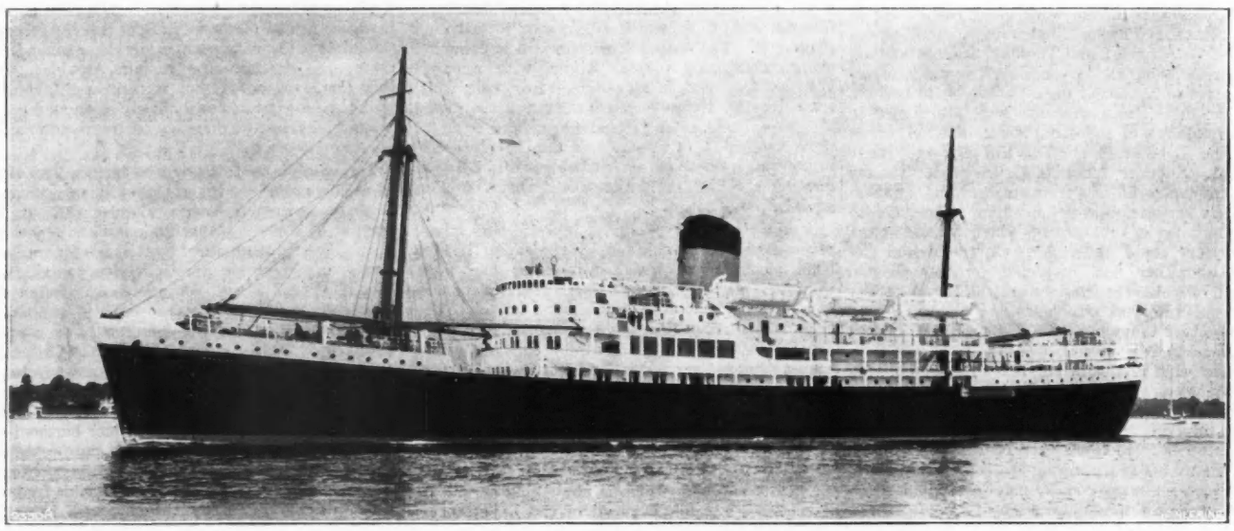


FIG. 1. VESSEL ON TRIAL.

## S.S. "COMMANDANT QUERÉ" FOR THE COMPAGNIE GÉNÉRALE TRANSATLANTIQUE.

THE passenger and cargo steamer Commandant Queré, a photograph of which is reproduced on this page, has been built at the Woolston Shipyards of Messrs. John I. Thornycroft and Company, Limited, for the mail and passenger service between Marseilles and Corsica. Ordered by the French Merchant Navy Administration, the vessel originally was to be operated by the Compagnie de Navigation Fraissinet but has now been handed over to the Compagnie Générale Transatlantique. In bearing the name Commandant Queré the vessel will preserve the memory of the Captain of the passenger ship Général Bonaparte which was torpedoed in 1943; Commandant Queré did all in his power to save the lives of his crew and passengers before going down with his ship.

The Commandant Queré was launched at Southampton on November 29, 1947, and a report of the ceremony, together with some details of the vessel, was given in ENGINEERING, vol. 164, page 538 (1947). The vessel, which is classed 100 A1 at Lloyds, has been designed in close collaboration with the owners so as to ensure that the special requirements of the service between Marseilles and Corsica should be met. The designed speed is 18 knots and during trials a speed of 18·63 knots was attained. The length overall is 363 ft., the moulded breadth 50 ft., and the depth to the upper deck 28 ft., while the displacement is approximately 4,400 tons. There are five decks, the lower deck extending forward and aft from the machinery space, while the main and upper decks run the full length of the ship. The promenade deck runs from the stern to the after end of a forward well, and the boat deck extends for approximately half the vessel's length. The hull is divided into ten main compartments by nine watertight bulkheads, which terminate at the main deck. There is a continuous double bottom which is arranged for the carriage of fresh water and oil fuel. In addition, deep fresh-water tanks are situated forward and aft while deep oil-fuel tanks are located between the forward end of the boiler room and No. 2 hold. Altogether there are three holds, numbers 1 and 2 holds together with 'tween deck spaces being forward of the bridge and No. 3 hold above the shaft tunnel. Between the boiler room and No. 2 'tween-deck space are large mail rooms, while cool rooms for the carriage of refrigerated cargo are arranged at the forward end of No. 3 hold. The holds are served by two 7-ton derricks for No. 1 hold, two 5-ton and one 15-ton derrick for No. 2 hold, and two 5-ton derricks for No. 3 hold, the cargo winches having been supplied by Messrs. Stothert and Pitt, Limited.

The vessel is engined by Parsons-type steam turbines arranged to drive twin screws through double-helical double-reduction gearing. The turbines were constructed by Messrs. Thornycroft and have been designed to give a maximum output of approximately 5,400 shaft horse-power at a propeller speed of 210 r.p.m.; the reduction gearing, however, was constructed by Messrs. Parsons. There is a high-pressure turbine and low-pressure turbine for each screw, the high-pressure turbines being of the impulse-reaction type while the low-pressure turbines are fitted with reaction blading only. Each high-pressure turbine consists of one double-bladed impulse wheel and five stages of reaction blading, there being seven rows of blading for each stage. There are 22 nozzles, giving a total area of 2·73 sq. in., the designed output being 1,000 h.p. at 3,460 r.p.m. under normal conditions and 1,350 h.p. at 4,018 r.p.m. on overload. The low-pressure turbines are fitted with 16 rows of reaction blading, and the designed output is 800 h.p. at 3,460 r.p.m. under normal conditions and 1,350 h.p. at 4,018 r.p.m. on overload. In addition, a three-row astern-impulse turbine is incorporated in each low-pressure turbine casing. Each is provided with 22 nozzles giving a total area of 1·65 sq. in., the designed output being 800 h.p. for each turbine at 135 r.p.m. of the propeller.

Steam for the turbines is supplied by two water-tube boilers situated in a closed stokehold forward of the engine room; a general view of the stokehold is given in Fig. 3, opposite. The boilers are of Messrs. Thornycroft's latest design and generally are similar to those fitted to the S.S. El Malek Foad which was built by Messrs. Thornycroft for the Khedivial Mail Line; an illustrated description of the boilers for this vessel was given on page 152, *ante*. The boilers are of the three-drum, single-sided pattern in which one side, together with part of the front and the back of each boiler is fitted with radiant-heat tubes only, while the other side in each case contains the main generating types, together with the superheaters, over which the products of combustion are passed. The boilers have been designed for a working pressure of 300 lb. per square inch and each consists of an upper steam-and-water drum and two lower water drums, both of which are connected to the upper drum by a system of steam-generating tubes. The main bank of tubes for each boiler is located towards the centre line of the ship and the water supply to the outboard lower drums is taken, in each case, through three 4½ in. diameter unheated downcomer pipes. The superheater tubes run in a longitudinal direction through spaces formed between the main generating tubes. The generating tubes and the superheater tubes for each boiler have heating surfaces of 2,780 sq. ft. and 470 sq. ft., respectively, the total heating surface, therefore, being 3,250 sq. ft. Under normal conditions the temperature of the superheated steam is 700 deg. F., while the evaporative capacity of each boiler is 21,000 lb. per hour with a fuel consumption of 1,535 lb. per hour.

The steam drums are fitted with de-superheaters arranged below the surface of the water. Their purpose is to provide for harbour conditions, when the whole of the steam generated is used for running the saturated-steam auxiliary services. Under these conditions, it is necessary to protect the superheaters from overheating and by fitting de-superheaters, the whole of the steam output from each boiler can be passed through the superheaters and the superheat subsequently transferred to the water in the steam drums. The feed water is delivered by two Weir turbo feed pumps, each of which can deliver from 43,000 lb. to 56,000 lb. of water per hour; in addition, there is an auxiliary feed pump which can supply both boilers in emergency, the delivery being 66,000 to 88,000 lb. per hour. The weight of each boiler is taken by four stools fitted to the water drums, and each pair of stools is provided with athwartships tie-bars which ensure the rigidity of the structure and limit the spread deformation of the tubes when the boiler is hot.

As previously mentioned, the two boilers are arranged in a closed stokehold. Combustion air is supplied by two motor-driven fans manufactured by Messrs. Keith Blackman, Limited, each of which can deliver 12,500 cub. ft. of air per minute at 2½ in. water gauge. Air heaters are not fitted, but the boilers are double-cased so that the air passes between the air casings and the hot surfaces of the boiler casings proper. Each boiler is fitted with five oil burners of Messrs. Thornycroft's own design. Each unit has six air doors arranged so that most of the air is caused to swirl rapidly during its passage through the throat. Some of the air, however, is trapped by radial vanes and directed towards the centre of the unit from which it flows in an approximately axial direction through openings in a cone which surrounds the burner tip. This central air serves to maintain a steady primary flame from which the main combustion originates. To enable the position of the flame to be regulated, the axial positions of the burner nozzle and cone have been made adjustable.

Most of the auxiliaries associated with the main propelling machinery are of the motor-driven type and the current for this purpose is provided by three 175-kW Diesel sets, the engines for which were provided by Messrs. Mirrlees, Bickerton and Day, Limited, and the generators by Messrs. W. H. Allen, Sons and Company, Limited. In addition, a 25-kW Diesel set is fitted on the boat deck for emergency use; this is a Lister set rated at 40 brake horse-power at 1,100 r.p.m. The 175-kW sets are situated in the forward part of the engine room and supply direct current at 220 volts. Other auxiliaries in the engine room include two Serck lubricating-oil coolers and a Sharples Vapor-tite lubricating-oil purifier. In addition, there is a Diesel-driven air compressor, the engine of which was supplied by Messrs. R. A. Lister and Company, Limited, and the compressor by Messrs. The Hamworthy Engineering Company, Limited.

A noteworthy feature of the Commandant Queré is the funnel, the top of which has been designed so as to lift the products of combustion well clear of the decks. The modern practice of fitting large funnel casings sometimes results in a zone of low pressure being formed immediately aft of the funnel; this is caused by the inability of the air displaced by the funnel structure to close in smoothly. There is a tendency, therefore,

# PASSENGER STEAMER "COMMANDANT QUERÉ".

MESSRS. JOHN I. THORNYCROFT AND COMPANY, LIMITED, LONDON.

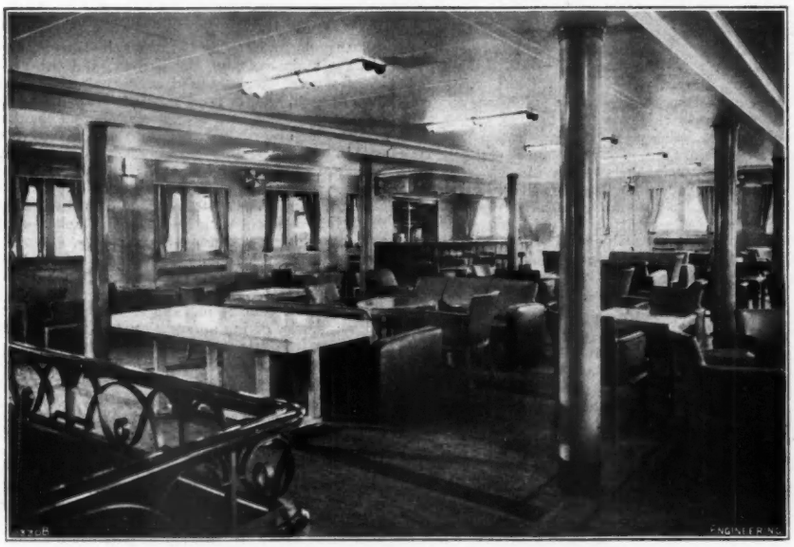


FIG. 2. TOURIST-CLASS LOUNGE, LOOKING FORWARD.

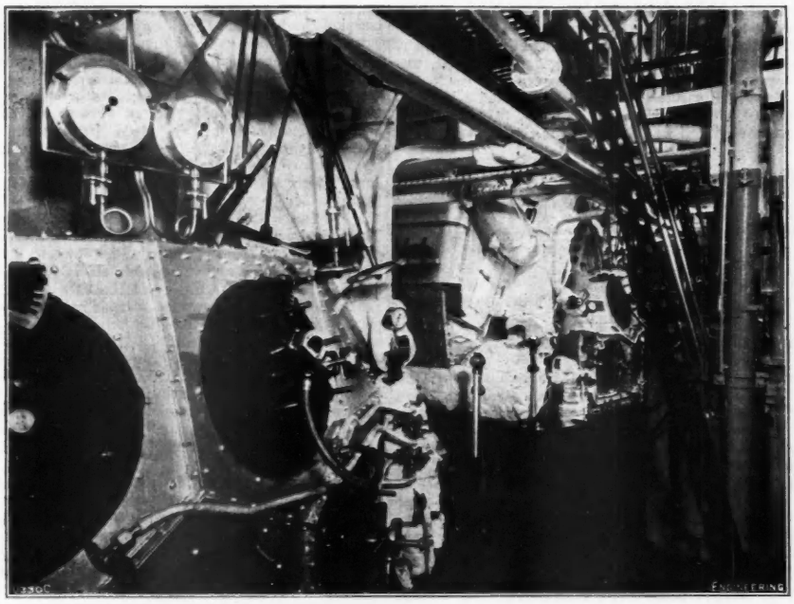


FIG. 3. GENERAL VIEW OF BOILER ROOM.

for the gases to sweep down into this low-pressure zone, and, under bad-weather conditions, cause annoyance to the passengers. This has been prevented on the Commandant Queré by shaping the top portion of the funnel so that in plan view it is in the form of an aerofoil section. This enables the displaced air to close in smoothly behind the top of the funnel and so prevents the formation of a low-pressure zone immediately below the issuing gases. Although this form of funnel gives the vessel a somewhat unorthodox appearance, it is exceptionally efficient in preventing the exhaust gases from sweeping down to the deck. This was shown on a demonstration run during which the boilers were caused to emit thick black smoke; although a strong wind was blowing at the time there was no tendency for the smoke to descend to the level of the bridge deck and this condition was maintained even though the vessel was headed some 30 deg. off wind.

The Commandant Queré has accommodation for 158 tourist passengers, 134 third-class passengers, and approximately 700 fourth-class passengers. The tourist dining saloon is on the upper deck and provides accommodation for 100 passengers at a sitting. From a vestibule adjoining the dining saloon, stairways lead downwards to the tourist cabins on the main deck and upwards to the lounge and bar on the promenade deck, which also accommodates further tourist-class cabins; the lounge and bar is illustrated in Fig. 2, above. The third-class accommodation is arranged forward on the main and upper decks. The dining room, lounge and bar, together with some of the cabins, are situated on the upper deck, while the remainder of the cabins are on the main deck; the cabins are fitted with either four or six berths. Fourth-class passengers are carried aft and large compartments are set apart for their use on the upper and main decks. As the journey between Marseilles and Corsica is only of short duration, these spaces are not fitted with berths, seating accommodation only being provided. Accommodation for the crew is arranged amidships on the main and upper decks and that for the officers in a deckhouse on the boat deck.

## LABORATORY CORROSION TESTS FOR STEELS.

AT a joint meeting of the Iron and Steel Institute and the British Iron and Steel Research Association, held at 4, Grosvenor-gardens, London, S.W.1, on June 17, to discuss various methods of protecting steel, one of the papers considered was the "First Report of the Methods of Testing (Corrosion) Sub-Committee." It was stated in the report, which was presented by Dr. J. C. Hudson, chairman of the sub-committee, that this body had been set up on November 6, 1945, as a sub-committee of the joint Corrosion Committee of the Iron and Steel Institute and the British Iron and Steel Federation. Briefly, the terms of reference of the sub-committee were, firstly, to investigate and report on the validity of methods of conducting corrosion tests on iron and steel and on protective schemes used for these materials. Secondly, they were requested to devise new methods of testing in this field, where necessary, and, thirdly, they were asked to collaborate in these matters with the British Standards Institution and other interested bodies, and, on request, to advise them with a view to the standardisation of appropriate test methods. On January 1, 1947, the sub-committee was taken over by the then newly-constituted British Iron and Steel Research Association, but retained its former name and terms of reference. The sub-committee then comprised 14 members, in addition to Dr. Hudson, and these represented the Royal Aircraft Establishment, the Armament Research Department, the Railway Executive of British Railways, the Ministry of Works, the Chemical Research Laboratory of the Department of Scientific and Industrial Research, the Post Office Research Station, Metallisation Limited, the Paints Division of Imperial Chemical Industries, Limited, United Steel Companies, Limited, the Pyrene Company, Limited, the Iron and Steel Institute, the British Standards Institution and the British Iron and Steel Research Association.

The object of the present report, Dr. Hudson stated, was to present the results of the experimental work undertaken by the sub-committee to date. This work had been conducted throughout on a collaborative basis in the laboratories of individual members of the sub-committee. So far, work had been devoted to the development of suitable tests for protective schemes applied to light-gauge steel components and had proceeded in three stages. In the first stage, sets of specimens representing a range of protective schemes applied to light-gauge steel were subjected to eight different types of laboratory test. On the basis of this work, a sea-water spray test, originally developed at the Armament Research Department, was selected as most suitable for immediate development. Other tests gave encouraging results and the sub-committee hoped to investigate these further. The second stage of the work concerned the reproducibility of the Armament Research Department (usually abbreviated to A.R.D.) sea-water spray test. This had been investigated by supplying standard sets of specimens to members of the sub-committee who had subjected them to test in their own laboratories. The reproducibility had been found reasonably good and it was concluded that the test was suitable for specification purposes. Finally, in order to determine suitable standards of performance that could be met by good present-day industrial practice, protective schemes had been applied to specimens under practical works conditions and the panels had then been subjected to the A.R.D. test in the laboratories of members. The A.R.D. test did not call for great technical knowledge on the part of the operators and required the minimum of equipment. It consisted simply in spraying the specimens with natural sea-water by a hand atomising spray, so as to coat the test surfaces all over with small droplets. After spraying, the specimens were enclosed within a box-like cover of sheet metal to retard the drying off of the droplets, a dish of water being also kept under the cover to retard the rate of evaporation. Spraying was repeated at intervals of 24 hours, except on Sundays, and the specimens were inspected each day immediately before this. The test was conducted throughout at ordinary laboratory temperature.

As a result of the investigation, it was concluded that the A.R.D. sea-water spray test could be regarded as suitable for acceptance purposes, although a final discussion on this point should be deferred until more data were available regarding the correlation between the behaviour under service and test conditions, respectively, of the protective schemes to which it was applicable. The main outcome of the investigations was that the sub-committee had been able to advise Technical Committee I.S.E./28 of the British Standards Institution regarding the preparation of a standard performance test and that, as a result, the latter had been able to compile Provisional British Standard specification No. 1391-1947. This was entitled "Performance Test for Protective Schemes Embracing Stoving Paints Used in the Protection of Light-Gauge Steel and Wrought Iron Against Corrosion."

## LABOUR NOTES.

THE Amalgamated Engineering Union, which has been holding its annual conference at Brighton since June 14, spent a considerable part of last week in discussing the engineers' claim to a national wages increase of 13*s.* a week, which has been rejected by the Engineering and Allied Employers' National Federation. About 2,500,000 to 2,750,000 employees would receive at least 13*s.* more weekly if the increase was granted, at a cost to the industry of some 80 to 90 million pounds annually. The demand for the increase is supported largely on the ground that there have been rises in the cost of living since the last increase in engineering wage rates in March, 1946. It is also contended that profits in the industry have been high.

Following a whole-day debate on June 17, the union's national committee rejected by 28 votes to 23, a proposal to enforce the claim by an immediate declaration in favour of national strike action. This proposal had come before the conference in the form of an amendment to a resolution which was passed unanimously on the following day. In this resolution, an immediate Government court of inquiry into the wages anomalies and profits in the engineering industry was demanded. The union's national committee further decided to ask the Confederation of Shipbuilding and Engineering Unions for a ballot on strike action to be taken, in the event of the findings of the proposed court of inquiry not being acceptable to the unions. A conference of the executive councils of the 37 unions which comprise the Confederation will commence on July 14 at York, and the engineers' wages question seems certain to be an important item on its agenda.

In the course of the discussion on wages, Mr. Jack Tanner, the union's President, supported the suggested Government court of inquiry, in preference to immediate strike action. He considered that such an inquiry, whether it was held in public or in private, would strengthen the union's case. The difficulties which faced the country at the present time were not sufficiently understood. He deplored the belligerent attitude of some and warned the conference that they would be doing the worst thing for their union, themselves and the country if they became involved in a dispute at the present juncture.

On the subject of nationalisation, Mr. Tanner adopted a somewhat cautious attitude. Although he advocated the prompt nationalisation of the steel industry he seemed to doubt whether the change-over of industry to public ownership would solve all, or even most, of our present problems. He said that it might if we were able to supply all our needs from our own resources, but we were far from being in that happy position. He added that nationalisation should mean efficient administration and the equitable distribution of our own resources. In other words, it would affect only a small part of our difficulties.

Sir John Stephenson, chairman of the shipbuilding sub-committee of the Confederation of Shipbuilding and Engineering Unions, placed the shipyard employees' case for a wages increase before the Shipbuilding Employers' Federation on April 21. The present national minimum plain-time rate is 5*l.* 4*s.* a week for skilled men and 4*l.* 5*s.* for unskilled, with proportionate increases for the semi-skilled and piece-work grades. These wage rates include war bonus and were fixed by national agreement between the unions and employers in April, 1946. Nearly 250,000 employees in England and Scotland are involved and, if the increases demanded were granted, the rates would rise to 5*l.* 19*s.* for the skilled classes, and 5*l.* for the unskilled, with adjustments for those on semi-skilled and piece-work rates: an overall minimum weekly increase of 15*s.*

The Confederation's demand was rejected by the Employers' Federation on June 18, when Sir Wilfrid Ayre, the Federation's President, replied to the employees' case at a joint meeting in London between representatives of both sides. Sir Wilfrid said that, after the fullest consideration of the case put forward by Sir John for the increases, the Federation felt that the advance was not justified. It seems probable that the Government's White Paper on Personal Incomes was in some measure responsible for the rejection of the claim. As is the case with the engineers' wages claim, the demands of the shipyard employees will also come before the Confederation's York meeting.

Mr. W. B. Beard, the general secretary of the United Patternmakers Association, in his introduction to the association's *Trade Report* for June, returns to the subject of real wages. After comparing the 1912 prices of some essential commodities with the pattermakers' wages in that year of 2*l.* 1*s.* for a week of 52 hours, he writes: "In the May *Report* I referred to the danger of inflation with wages chasing prices; it would appear from the comparison with 1912 that wages have been following rising prices ever since and, although the purchasing power of the people as a whole has risen and become more evenly divided, the amount that the pound will buy is probably relatively less than before the 1914 war."

After emphasising that the trade unions are now concerned with many things besides the size of the wage packet, such as holidays with pay, safety precautions, working conditions and hours of labour, Mr. Beard says that a Labour Government must inevitably involve unions more and more in national policy. Education, social security, industrial efficiency, etc., require national and local committees on which trade unionists serve, and the whole problem of wages is bound up with such questions, for income tax is used to pay for many of these things.

Mr. Beard concludes by saying that "in nationalised industries like coal, gas, electricity and transport, wages largely determine the cost of these products or services to the community and have their effect on production costs and prices in every other industry. Every phase of activity of the State has a relation to wages and the wage packet. It should, therefore, be our policy to obtain real wages rather than money wages. This involves some restraint, increased production and a realisation of their responsibility by every individual. It is not enough to expect others to play their part, it is a job for all."

The official index figure of retail prices for "all items" rose by two points, during the four weeks ending April 13, to a level of 108. This increase was largely the result of the increases in the duties on alcoholic drink and tobacco. For the food group only, there was a rise during the same period of about one half of one per cent., but, to the nearest whole number, the index figure for this price group remained, unchanged, at 109. The index measures changes in the average level of retail prices, in the United Kingdom, compared with their level on June 17, 1947, when the index started and which is taken as 100.

The new tribunal which was set up to inquire into the case of the 11 dockers whose refusal to move a cargo of zinc oxide ultimately led to the present unofficial strike at the London docks, met in London on June 17, under the independent chairmanship of Sir Robert Aske, K.C. Two representatives of the dockers and two of the employers also sat on the tribunal. A previous tribunal had failed to agree.

After a long hearing, during which it appeared that the 11 men had in all refused four times to move the cargo at the agreed rate, the tribunal modified the penalties imposed by the Dock Labour Board. The period during which the men would not be entitled to attendance money or to the guaranteed minimum wage was reduced from 13 weeks to 2. The Board's decision to suspend the men for a week, however, was upheld. The men had claimed payment at the rate of 5*s.* a ton for the cargo, in lieu of the agreed rate of 3*s.* 4*d.*, on the grounds that it was "dirty" work. The tribunal also confirmed that the rate to be paid for zinc-oxide cargo should be the agreed rate.

The reduced penalties were not accepted by the dockers and the strike, though unofficial and condemned by the Transport and General Workers' Union, to which the dockers belong, has continued. Wider issues than the original dispute over the penalties imposed on the 11 men are being raised. There is a demand that the union should start negotiations at once for the abolition, or drastic reduction, of the disciplinary penalties provided by the Dock Workers Regulation of Employment Order, 1947, under which the Dock Labour Board acted. It may well be that a demand for such revision of the Board's powers will accompany a return to work.

Dock-gate meetings have been held by both the strike committee and by the union. Rival meetings have also taken place in Victoria Park and at the Royal Albert Hall. The latter, held on Tuesday, was organised by the union and addressed by Mr. Arthur Deakin, the general secretary. Those present were estimated to number between three and four thousand. They passed by a large majority a resolution to return to work. Mr. Deakin promised that a national delegate conference of the union would be held to tackle the question of the disciplinary powers provided by the dock labour scheme.

## MOBILE LOCOMOTIVE-TESTING PLANT; L.M.S. RAILWAY.*

By H. I. ANDREWS, Ph.D., M.Sc.(Eng.), A.M.I.Mech.E.

(*Concluded from page* 599.)

THE underframe (which supports the Diesel generator set, the main resistors, the battery, and the blowers) is, of course, much heavier than that of a standard motor-coach, but it is of similar construction, being built up of channel sections by riveting. The openings in the roof above the main resistors are closed when not in use by sliding covers operated from within. Standard braking equipment is fitted, including a guard's hand brake. The suspension, in the design of which Mr. T. H. Sanders was consulted, includes swing-link bolsters with four nests of helical springs, each nest having an outer coil of circular section and an inner coil of rectangular section giving a static deflection of 2½ in. under load. The side bearing springs, which are of laminated form with reverse camber, give a static deflection of 2¼ in., and are supported by twin-coil auxiliaries giving an additional deflection of 1¾ in. The resonance frequency of the bolster springs is 129 cycles per minute, and that of the side bearing system is 95 cycles per minute. With this arrangement, resonance of the side bearing system is unlikely to occur, but should a section of bad track be encountered having 60-ft. rails, the critical speed for resonance of the bolster springs would be 88 miles an hour.

The main generators of the three units are electrically identical and are continuously rated at 375 h.p.; they differ only in gear ratio, and in the method of suspension. Since each is connected directly to its own resistance bank, no question of paralleling arises, and they are therefore fitted with slip-rings and generate three-phase alternating current at up to 700 volts, and at a frequency of up to 70 cycles per second, depending on the speed. Apart from the slip-rings, the generators are constructed on the lines of direct-current traction motors. The field system has four poles wound for separate excitation, no interpoles or compensating windings being needed, and the armature winding is arranged like a normal lap winding of a direct-current machine. Each generator is force ventilated by its own motor-driven blower, so that its cooling is independent of the speed of the train.

Each loading resistor has a continuous rating of 300 kW, corresponding to that of the associated generators. Each resistor is composed of a bank of 12 resistance boxes, the resistance element of each box being in the form of a single-looped strip of low-silicon steel. The resistance bank is carried in a steel framework and enclosed in steel sheeting, open at the top and bottom, forming a "chimney" up which air is forced by a motor-driven fan at a mean velocity of about 870 ft. per minute. The narrow steel strip is naturally a very efficient means of heat transfer, and, when under full load, reaches a temperature of 600 deg. F. after about 20 minutes, while the temperature of the air discharged rises to about 350 deg. F. Each resistor has its own switchboard, with an isolating switch and fuses, hand switches for adjusting the resistances to the appropriate speed ranges for the various combinations of units, and remotely controlled contactors for altering the resistance values at low speed.

The bogies of the higher-speed units Nos. 2 and 3 are similar to those of the low-speed unit, except that the generators are fully supported from the bogie frame. These generators have extended arms which are bolted to brackets at the headstocks. To ensure that no force can be transmitted by the generator castings, the noses are supported in resilient mountings like those of the low-speed bogies. The gear wheels are mounted on short hollow quills which are carried in bearings attached to the generator frames, corresponding to the suspension bearings of the low-speed generators. The axles pass freely through these quills, sufficient radial clearance being left to allow for the vertical movement of the axleboxes. The two sets of bogies are identical, except for the gear ratios, which are 35 : 86 for the high-speed, and 27 : 86 for the medium-speed bogies. The gear ratio of the medium-speed bogies can be altered to that of the high-speed bogies by merely changing the pinions and gearcases, the necessary alteration in the bearing centres being obtained by rotating the split sleeves of the quill bearings in their housings, these sleeves being eccentric by an amount equal to half the difference between the gear centres. At the same time, the generators must be moved the requisite distance in the bogie frames, bolt holes being provided for each position.

The flexible axle-drives are of a type which has been developed by the author, in association with the English Electric Company, for use in high-speed motor-coaches,

* Paper presented at a meeting of the Institution of Mechanical Engineers, London, on Friday, April 16, 1948. Abridged.

## MOBILE LOCOMOTIVE-TESTING PLANT.

Fig. 7.

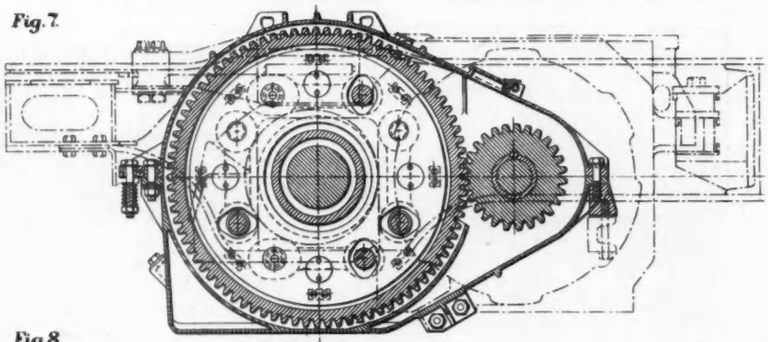


Fig. 8.

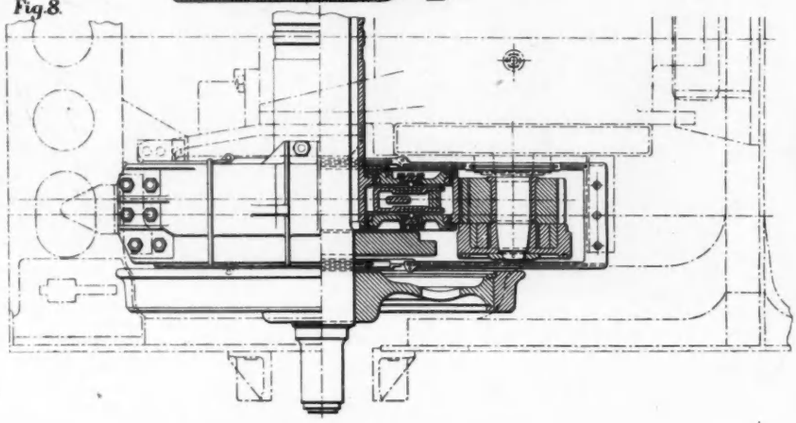


Fig. 10.

Fig. 11.

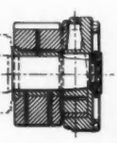
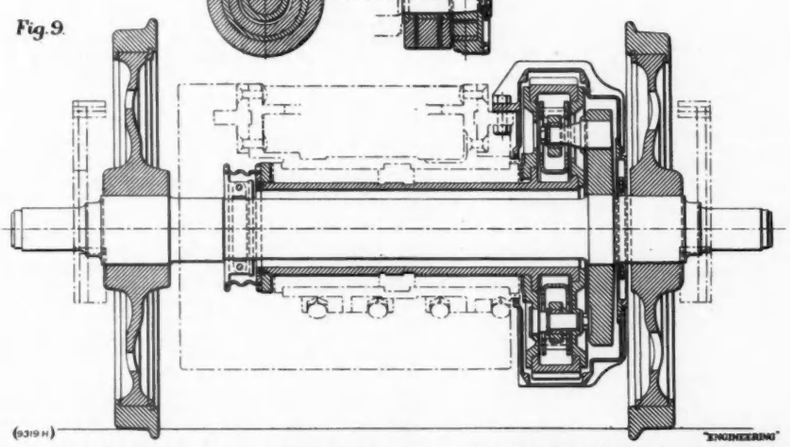


Fig. 9.



(9319 H) "ENGINEERING"

with the object of improving riding and of reducing the excessive wear such vehicles usually produce upon the track, owing to their unsprung weight. They are designed to permit a vertical movement of the axleboxes in the axlebox guides of $\pm \frac{1}{4}$ in., and can also accommodate lateral displacement of the axle or out-of-alignment. The drive, which is contained within the gearwheel, consists of four links and a floating member, and connects the gearwheel with a disc crank mounted on the axle, as shown in Figs. 7, 8 and 9, on this page. This arrangement does not introduce any angular discrepancy between the relative positions of the driving and the driven members, a feature of particular importance, as the drive is required to operate at speeds up to 900 r.p.m., and it has been found by experience that at high speeds any such irregularity in the motion of a drive inevitably leads to excessive wear or failure of the parts. A resilient pinion, which is shown in Figs. 10 and 11, and in Fig. 12, on page 622, is introduced to cushion any shocks which may be transmitted from the road wheels to the generator armature. All the links of the drive are fitted with needle-roller bearings, the two bearings at the crankpins having outer races in the form of spherical bushings, while the two corresponding bearings on the floating member are of a special form giving only 2 deg. of angular freedom, as shown in Fig. 13, on page 622. The floating member, which is of forged steel and of U-section, is supported laterally from the gearwheel by roller bearings of a simple form having a single roller, the outer races of which are inserted through the side members of the gearwheel. The gear rim, in which the teeth are cut, is forged of nickel-chromium-molybdenum steel, the side members being steel castings.

The resilient pinion, Figs. 10, 11 and 12, which is mounted on the armature shaft of the generator, comprises three members, the pinion, spring, and spring cover. The pinion is free, of itself, to revolve around the armature shaft on a bronze sleeve bearing, and carries a shaped extension to accommodate the spring. The spring is made of steel plate bent back upon itself as shown in Fig. 12, the springs for the medium-speed unit having a single plate, while those of the high-speed unit have two plates. The spring cover is keyed to the armature shaft, and has jaws engaging with the ends of the spring projecting from the pinion housing. The torque from the pinion is thus transmitted to the armature shaft through the spring, which tends to close whatever the direction of rotation. The use of a disc crank on the axle enables the drive to be enclosed completely by the gearcase, thus securing greater protection for the moving parts, and improved lubrication. The gearcase is in the form of two Alpax castings, and is bracketed from the generator frame, having a sliding seal to accommodate the axle. The drive is lubricated by oil, the interior of the gearcase being shaped and fitted with baffles so that the gearwheel itself becomes a pump automatically supplying oil to the gear teeth.

The controls of the unit are contained in the electrician's compartment. On one side of this compartment is a panel carrying the main thyratron controls for the unit, together with a thyratron voltage regulator for the alternating-current supply, and a set of master controls which can be used, with a tachometer generator driven from one of the axles, for independent operation of the vehicle. On the opposite side is a panel carrying the controls and instruments for the main generators, for the auxiliary supply, and for the exciting generators. The loading of the main generators is controlled by their excitation, and switches are provided for individually shorting out their fields if necessary. As the auxiliary power supply may be obtained from either the auxiliary generator or the battery, the usual arrangements are made for paralleling these to each other and to the train bus-bars, the loading of the generator being regulated by a hand rheostat in its field circuit. A multiple contactor, actuated by a reverse-current relay in the armature circuit of the auxiliary generator, provides for operation of the clutch and change-over of the machine from generating to motoring should failure of the engine occur. Thus, if for any reason the torque of the engine fails, and the armature current in the auxiliary machine becomes reversed, the thrustor is actuated from the alternating-current supply, declutching the engine; the field resistance of the auxiliary machine is altered, and an additional differential field is introduced, so that the speed of the three machines remains constant. The various auxiliaries and the auxiliary machine can then be supplied from the battery for about an hour, irrespective of the working of the engine, which may be stopped if required. This action can also be initiated by push button, or by a thermostat indicating overheating of the engine. If the engine is running at its normal speed, the procedure may be reversed by depressing another push button on the panel, when the auxiliary machine resumes generating. A motor starter, with starting resistances, can be brought into use should the three machines be required to start without the use of the engine. At the rear of the compartment is a further panel carrying the switchgear for the fans and blowers, and also a number of warning lights actuated by thermostats in each generator and above each main resistor. Immediate warning of any serious overheating is given in each electrician's compartment, and in the dynamometer car.

The function of the automatic control is so to regulate the loading of the main generators that the speed of the train, as indicated by the voltage of the tachometer generator, is maintained at some preset value, irrespective of changes in the drawbar-pull of the locomotive or the resistance of the train. It can, of course, also regulate in accordance with any other factor directly affected by the generator loading, providing such factor can be represented as a voltage; for example, it may be arranged to maintain constant drawbar pull. Also, by adjustment of the preset value, any desired function of speed, tractive effort, etc., may be reproduced. The control consists of the master control and a valve amplifier on the dynamometer car, and controlled thyratron rectifiers feeding the exciting generator field on each of the braking units. While these controlled rectifiers are identical in construction, they may be adapted by switching, so that one rectifier acts as "leader," while those of which ever other units may be connected work as "followers." The general principles upon which this apparatus has been designed have already been described by Whiteley in his papers* on the thyratron and servo systems.

Fig. 14, on page 622, shows one of the automatic control panels on the braking units. The master controls for independent operation of the unit may be seen on the right-hand section; the voltage regulator for the alternating-current supply occupies the lower portion of the central section; and the signal amplifier is on the left-hand section of the panel. To prevent loss of control due to failure of a tube, each valve or thyratron is duplicated in parallel, so that, while the load is normally shared between the two tubes, either is capable of sustaining the full load should its partner fail. In the case of the valves, failure is indicated by a milliammeter in each anode circuit, but on failure of any thyratron the resulting lack of balance operates a relay lighting a red lamp in the electrician's compartment in each unit. The voltage regulator is a grid-controlled thyratron rectifier supplying direct current to the field of the alternator, so that its output voltage, when rectified, balances a fixed reference potential obtained from voltage stabilisers. Incorporated with

* *Jl. I.E.E.*, vol. 78, page 516 (1936); and vol. 93, page 353 (1946).

## MOBILE LOCOMOTIVE-TESTING PLANT.

FIG. 12. RESILIENT PINION.

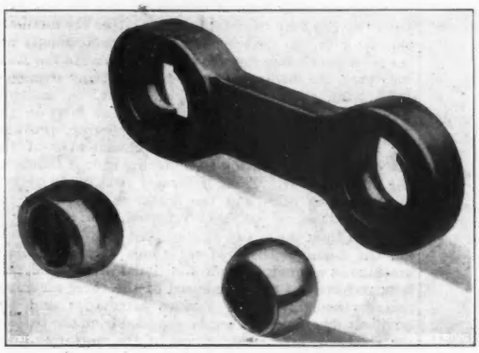


FIG. 13. FLEXIBLE AXLE-DRIVE LINK.

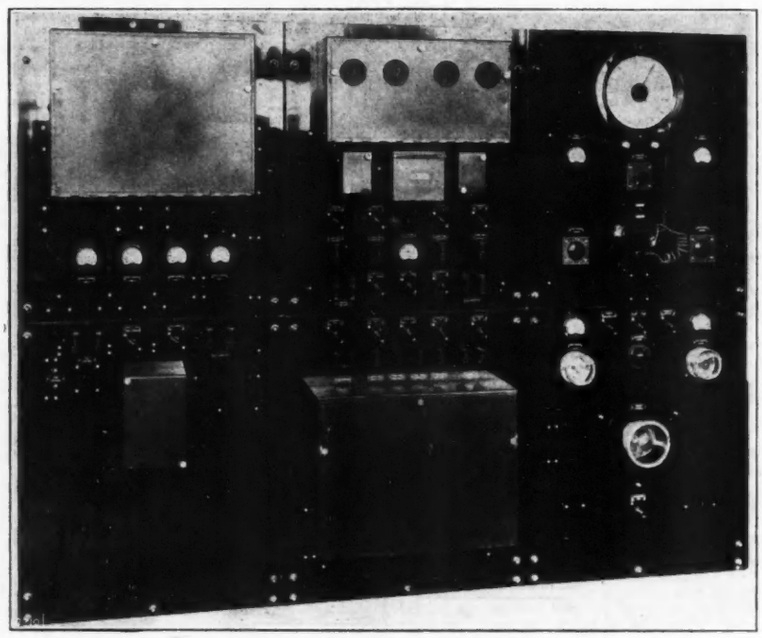


FIG. 14. AUTOMATIC CONTROL PANEL.

the master controls is the telephone equipment which is of the laryngaphone pattern; in this the microphone absorbs the vocal sounds by contact with the throat or the side of the face, so that all extraneous noise is eliminated. A telephone is provided at each working position on the train, and connections both for ringing and speaking follow the natural lines of communication required during a test. The three central positions in the recording and control compartment of the dynamometer car each have simple switching panels for connecting any desired "family" of outstations.

It was realised from the outset that an apparatus of this type could be employed for a wide variety of work, and care was taken that the equipment should be as flexible as possible for adapting it to any tests that might be required. Provision has been made in the equipment for testing Diesel locomotives, and space has been left on the dynamometer car and each unit for the temporary installation of meters for testing electric locomotives or trains. During the summer of 1939, measurements were made of the coal consumption of locomotives on the Derby-Burton-Leicester circuit, and a further series of similar tests was projected for the following winter on the line between Skipton and Carlisle. These routes have too severe gradients to be really suitable for testing, but were chosen so that experience might be gained of the working of the control equipment. In 1947, a comprehensive series of resistance tests was carried out on the lines between Rugby and Peterborough. For these tests the train is marshalled as follows: locomotive, mobile testing unit, dynamometer car in reverse, and vehicles to be tested. The speed of the train is maintained constant by the resistance of the braking unit, and the resistance of the vehicles on suitable sections of track is measured directly by the dynamometer. These results, of course, must be corrected for gradient and wind, but no allowance need be made for acceleration. Simultaneous readings are taken of wind speed and direction, the additional resistances due to which may be analysed so that the resistance of the train in any wind can be calculated. This form of test will also determine the performance of railcars or motor-coaches, as measurement may be made at constant speed of both the running resistance and the net tractive effort, from which the gross tractive effort can be calculated.

The equipment may also be employed in connection with a large number of railway investigations other than the measurement of performance. For example, tests have already been made in which the speed of the train or the braking effort have been controlled in accordance with some pre-arranged function. Thus the resistance of a train measured on some particular section of track may be reproduced elsewhere, or the performance of a locomotive can be simulated on a line over which it is not permitted to run. Valuable observations have also been made under controlled conditions in relation to such problems as the creep of tyres, and the coefficient of friction during wheel slip.

## THE INSTITUTION OF MINING AND METALLURGY.*

By S. E. TAYLOR, D.S.C., M.A.

I PROPOSE to review briefly the present position of the Institution and make some observations on the future; but first I am going to look back and recall some of the achievements of the Institution during the 56 years which have passed since its foundation. During the early years, the Institution was mainly concerned with the publication of technical papers. This has been, and always will be, one of its most important functions. One of the earliest and most interesting of the Institution's activities was in 1894, when the nucleus of a library was formed and the question of abstracting from other journals was considered. At a very early stage we find the Institution taking a deep interest in the education and training of mining engineers and metallurgists. In 1902, five scholarships of 50*l.* each were granted and by 1905 post-graduate courses were available to students to enable them to obtain experience at mines within the Empire and in the United States. In 1904, a Government Departmental Committee was appointed to inquire into the working of the Royal College of Science and the Royal School of Mines, and to consider what improvements could be made in regard to staff, buildings and appliances. The Institution gave evidence before this Committee and took an active part in the affairs which led to the formation of the Imperial College of Science and Technology in 1907 and the erection of a new Royal School of Mines building in 1910. From 1904, we find important work being done on standardisation of weights, measures and terms, screens, mine accounts, and cost sheets.

An important milestone in our history was the year 1915, when the Royal Charter of Incorporation was granted. The objects and purposes of the Institution were then laid down as the advancement of the science and practice of mining and metallurgy and to afford a means of facilitating the acquisition and preservation of that knowledge which pertains to the profession of a mining engineer and metallurgist.

The 1914-18 war brought to the fore the importance of the mineral resources of the Empire, and the Institution took the lead in framing estimates of these resources and advised the Government on the subject. Arising out of these activities and with a view to promoting closer co-operation between the mining and metallurgical institutions of the Empire, the Institution initiated the first Empire Mining and Metallurgical Congress, held at the Wembley Exhibition in 1924. At the Congress the Empire Council of Mining and Metallurgical Institutions was formed. Other Congresses were held in Canada in 1927 and in South Africa in 1930, but owing to economic and other adverse conditions no further Congress took place. In addition to their technical advantages, these Congresses had a most valuable effect in fostering a closer co-operation between mining engineers throughout the Empire.

Already we were working closely with the Institution of Mining Engineers, with whom we now share a valuable joint Library; we have worked together on common problems, such as ventilation, conditions of heat, dust and silicosis, with mutual benefit. In the 1939-45 war, the Institution again rendered national service in connection with the supply of strategic base metals and with metallurgical problems. Finally, I will mention two recent achievements of the Institution. In the field of metallurgy combined efforts by all those interested have been directed to raising the numbers and improving the training of metallurgists. The Institution's representations to the Government on the subject of mine taxation met with considerable success, valuable concessions being obtained for mining companies. This work has now been passed over to the recently-formed British Overseas Mining Association.

As a conclusion to this review of our past history I will briefly remind you of the outstanding technical changes that have occurred during the life of the Institution. In mining, there is the ability to reach great depths, involving solutions to the problems of heat, through ventilation and air conditioning, and the problem of rock bursts, through ground control and support. In metallurgy, the discovery and perfecting of the cyanide and flotation processes have had a profound effect on many mines and mineral deposits. In these historic advances in the science and practice of mining and metallurgy British engineers have played a prominent part and their work is recorded in many valuable papers in the *Transactions* of the Institution.

Another great change has been in the handling of large tonnages as the result of skilful planning, organisation and mechanisation. The resulting spectacular reduction in costs has brought vast low-grade deposits into profitable exploitation. In this advance British engineers are not as prominently identified and we have not published many papers on operations of this type, except as regards sampling of such deposits. Then there is the rapid increase in the economic importance of such minerals and ores as bauxite, gypsum, china clay, phosphates, barytes and the ores of the less common metals. British engineers have played an important part in the development of these industries and more papers on this work would be welcomed.

We now come to the present day. Our total membership is about 2,200, of whom 650 are full members, 1,150 are associates and 400 are students. Sixty per cent. of all our members are abroad. Approximately 30 per cent. are located in the larger mining fields and the other 30 per cent. are scattered over 70 countries. Many of the members who are abroad visit this country from time to time and so are able occasionally to attend our meetings, but for many of our members the Institution is a distant and impersonal organisation which expresses itself almost entirely through its *Bulletin*.

* Presidential address delivered before the Institution, on Thursday, May 20, 1948. Abridged.

Turning now from the past and the present to a consideration of the future, we shall do well first to ask ourselves: are we fulfilling the purposes and objects of the Institution in the best possible way? And: what are we going to do in the future to fulfil these objects? One of the matters in hand is the encouragement being given to the education and training of metallurgists. Great efforts are being made by the industries and the technical societies concerned to overcome the dearth of metallurgists. Already the opportunities and inducements offered are bearing fruit.

These efforts to attract and train metallurgists have aroused thoughts about the training of mining engineers. Already the theoretical and practical training at the Schools of Mines and Universities is of a high order, but engineers trained in the United Kingdom lack the beneficial admixture of practical work in an operating mine with their technical college studies. As a result, our engineers generally complete their technical course and then learn the practical side as part of their first job. Some of the larger companies undertake this as a regular part of training their junior staff; other companies are not in a position to do this and necessarily expect a newly-engaged employee to take on a real job as soon as possible after he joins. Thus his practical experience becomes confined to his own particular job, and to widen his experience many a mining engineer seeks to move round and change his job. It seems to me that it would be to the benefit of the employing company and the young mining engineer if he could acquire some of this practical experience as a regular part of his training; this, I take it, is one of the ideas underlying travelling scholarships. Some extension of this process for selected students is, I suggest, worthy of close consideration.

Another of the matters in hand is the publication, in conjunction with the Institution of Mining Engineers, of the proceedings of the Silicosis Conference held in April last year. It is unfortunate that difficulties have so delayed this publication but there is no doubt that it will be a world-wide authoritative treatise on the subject. Following the same policy of taking intractable problems and summoning all available authorities into conference whereby it is hoped to achieve a measurable advance towards their solution, it has been decided to turn to a metallurgical problem and arrangements are being made for a Symposium on the Refining of Non-Ferrous Metals next year. It is the intention to arrange similar functions from time to time as the need arises. The first Wernher Memorial Lecture was delivered at the Silicosis Conference last year: it is hoped that, in future, these lectures will be delivered every two years. While these matters are being actively pursued there is no slackening in our standard method of facilitating the advancement of the science and practice of mining and metallurgy through the publication of technical papers. During the past session we have published fifteen papers and our Publications Committee have several papers under consideration.

One important matter for the future is the Fourth Empire Mining and Metallurgical Congress which will be held in the United Kingdom next year, and in this connection the Empire Council has now been re-formed. However energetic and efficient the organising Committee may be, they alone cannot make such a Congress a success. I would therefore appeal to all members of this Institution who can take part, and also to the members of our sister Institutions overseas, to give generously of their knowledge, experience and ideas so that we may learn from one another and so advance the knowledge of all. The success of a Congress can be measured by the amount of work and preparation put into it beforehand. It is the individual and painstaking work of the authors of papers during the next few months that will lay the foundations of the success of this Congress and it is the determination of members to take part and prepare for the discussions that will set the seal on the success of the Congress.

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INSTRUCTIONAL COURSES IN SERVO-MECHANISM.—The Ministry of Supply announce that the Interdepartmental Technical Committee on Servo-Mechanism have secured the co-operation of the Ministry of Education, the Scottish Home Office and various educational institutions throughout the country with the result that courses, including lectures on the basic principles of automatic control, general applications, and applications of particular local significance, are to be held during the next few months in various centres. So far, the courses scheduled for this year are to be held at the Central Technical College, Birmingham, from July 5 to 9; the Northampton Polytechnic, London, E.C.1, from July 12 to 16; the Central Technical College, Birmingham, from August 30 to September 4; and King's College, Newcastle-upon-Tyne, from September 1 to 3. Further particulars regarding the courses can be obtained from these establishments.

## NOTES ON NEW BOOKS.

*Concrete Waterproofing.* By L. E. HUNTER, M.Sc. (Eng.), A.M.I.C.E., A.M.I.Struct.E. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 12*s.* 6*d.* net.]

THE author classifies concrete-waterproofing methods into integral waterproofing, and surface waterproofing, the latter being sub-divided into "internal" and external coatings. Integral waterproofers are materials added to the cement or concrete, either by the manufacturer or during the mixing at the site. Internal surface coatings are usually employed to stop leaks, and are rather uncertain in their results. External surface coatings are usually bituminous or asphaltic coatings, which can be used in one or two coats for damp-proofing, or in three coats for resisting a large head of water. Approximate analyses are given for typical compounds. The results of tests on waterproofing compounds, especially those described in the United States Bureau of Standards Report of 1936, are reviewed. Mr. Hunter gives practical information, illustrated with sketches, on the integral waterproofing of structures, and the application of waterproof renderings, and there is a chapter on specifications for waterproof concrete. The origin, manufacture, and application of mastic asphalt are fully described, and, rather curiously, although the author is careful to point out that the British Standards Institution have standardised the spelling of asphalt without an "e," he himself consistently writes "asphalte." The last two chapters are on the cement-gun process, and repairs and joints in water-bearing structures.

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*The Engineering Outlook.* Offices of ENGINEERING, 35 and 36, Bedford-street, Strand, London, W.C.2. [Price 5*s.* net; by post, 5*s.* 3*d.*]

FOR more than 20 years, the annual series of articles on "The Engineering Outlook" has been a regular feature in the pages of ENGINEERING, and together these reviews present one of the most valuable continuous surveys in the technical Press of this or any other country of the economic fluctuations of the industries concerned. Now, for the first time and in response to numerous requests, a reprint is available of the series for the current year, which appeared weekly in our columns in the issues from January 2 to April 2, and it is believed that they will be found of both interest and value to engineers and economists alike. As is remarked in the introductory survey, production statistics for the engineering industry as a whole do not exist; but there is a great deal of factual information now available in various official returns, which are freely quoted. In practically every case, these are summarised in tabular form, with comparative figures for a number of previous years, and frequently they are supplemented with further details, supplied by the trade organisations concerned and checked by them before publication, which are not to be found in public sources of reference.

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*Blackpool Tower.* Edited and published by L. ASH-LYONS, Yard 119, Highgate, Kendal, Westmorland. [Price 2*s.*]

POPULAR guide-books of the type associated with seaside resorts are somewhat outside the usual scope of our review columns; but this little brochure is of a special and distinctive character, in that it contains a number of photographs showing details of the construction of the Tower, as well as reproductions (necessarily much reduced) of some of the arrangement drawings which accompanied the description of the structure in the 59th volume of ENGINEERING (1895). The Blackpool Tower is now the only example of its type remaining in this country. The Eiffel Tower, built for the Paris Exposition of 1889 and of wrought iron, set the fashion; Blackpool's steel tower followed in 1894–5 and the New Brighton tower, about 100 ft. higher than that at Blackpool, a couple of years later. A still more ambitious project at Wembley, Middlesex, was not completed, and the tower at New Brighton was taken down towards the close of the 1914–18 war.

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*Company Accounts under the Companies Act* 1947. By F. SEWELL BRAY, F.S.A.A., and H. BASIL SHEASBY, F.S.A.A. Society of Incorporated Accountants, Incorporated Accountants Hall, Victoria Embankment, London, W.C.2. [Price 2*s.*, post free.]

As experience had revealed certain defects in the Companies Act, 1929, a Committee, under Mr. (now Lord) Justice Cohen was set up by the President of the Board of Trade, in June 1943, to review, *inter alia*, the "requirements prescribed in regard to the formation and affairs of companies and the safeguards afforded for investors and for the public interest." The Committee reported two years later. One of the defects in the 1929 Act was the inadequacy of the legal requirements concerning the contents of the accounts as presented to shareholders, by which a number of diverse items could be included in a lump sum, so obscuring the true position. This has been remedied in the present Act, which provides that every balance sheet of a company shall give a true and fair view of the state of affairs of the company at the end of its financial year, and every profit and loss account a true and fair view of its transactions for that year. A company's balance sheet and profit and loss account are required to comply with the requirements of the First Schedule of the Act, and these requirements are dealt with very clearly in the present booklet. It is printed on large quarto pages, the left-hand pages containing all the items which statutorily form the liabilities, and the right-hand pages, those which similarly form the assets; in the part referring to the profit and loss account, the statutory debits and credits are similarly set out on their appropriate facing pages. All the items required by the Schedule to be shown in the accounts are included, and referenced to the Schedule. Full explanatory notes, referenced to the Schedule and to relevant sections of the Act and of the principal Act (that of 1929), complete the work, which reduces to relative simplicity a most involved topic. As the accounting provisions of the 1947 Act are to operate on July 1, the publication of the booklet is timely. It should be of interest not only to those engaged in the preparation of accounts of public companies, but also—perhaps more importantly—to those interested in their financial operations as shareholders or investors.

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*Fitting.* By A. E. LEESON and P. SAMPSON. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 7*s.* 6*d.* net.]

THIS 120-page book contains very little general text, but describes, by means of well-captioned sketches and terse explanatory notes, the correct treatment and use of common types of hand tool, and the methods of working out and setting up work for machining. Techniques such as cold bending, riveting, forging, soldering and welding are illustrated, as well as the use of machine-tool accessories, and the carrying out of simple turning, grinding, milling and shaping operations. The notes are set out in block type, and though brief, they give, together with the sketches, sufficient information for the novice or learner to understand the particular subject or operation being described. The book should prove a valuable guide to the young engineering or tool-room apprentice, especially as it illustrates various examples, which if carried out, will form the basis of a sound practical training. It should also prove equally useful to the general mechanic, or to the amateur who possesses a small workshop.

## CATALOGUES.

*Paints and Varnishes.*—Several leaflets describing their products, which include ready-mixed paint, hard-gloss paint, enamel paint, floor paint, clear varnish and "wrinkle" enamel, have been published by Messrs. Cartwright Limited, Henshaw Works, Oldham, Lancashire.

*Expanded-Metal Resistances.*—Details of the expanded-metal resistances manufactured by them for use on trolley 'buses, rail motor coaches and welding machines are given in a well-illustrated catalogue issued by the Expanded Metal Company, Limited, Stranton Works, West Hartlepool, Co. Durham.

*Electric Water Heaters.*—The Dominion Electric Heating Company, 23, Market-street, Birkenhead, have published a pamphlet dealing with the instantaneous electric water heater they have designed for domestic purposes. The loading is 5 kW, and it is stated that scalding water can be obtained 15 seconds after switching on from cold.

*"Perspex" Tubes and Cylinders.*—A leaflet price list of welded tubing of clear plasticised Perspex has been issued by Evolite Plastics Limited, 325-327, Latimer-road, North Kensington, London, W.10. The outside diameter, wall thickness, and price per foot are given, and some data on the physical and mechanical properties of the material are included.

*Mixing Machines.*—A booklet we have received from Messrs. Baker Perkins, Limited, Westwood Works, Peterborough, describes that firm's range of machines for mixing almost any materials—powders, liquids, plastic mixes, foods, rubber, etc. There are numerous types and sizes of their Universal machines, but, in general, it is advisable to submit particulars of the materials to be mixed before deciding on a particular machine.

*High-Grade Steels.*—Two catalogues relating to steels have recently been issued by Messrs. Hadfields Limited, East Hecla Works, Sheffield. The first, No. 463/C, contains tabulated and other data on billets, bars and slabs of British Standard Specification No. 970 Enseries quality, for use in motor-car and general engineering applications. The other catalogue, No. 473, is concerned with heat-resisting steels and gives particulars of the range, physical and mechanical properties, creep strength, and machining and welding qualities of the firm's H.R. series of steels.

## "ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

*The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.*

*Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.*

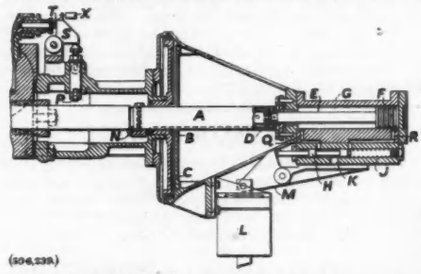
*Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.*

*The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.*

*Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.*

### FURNACE APPARATUS.

**596,239. Electrically-Driven Soot Blower. The British Thomson-Houston Company, Limited, of London, and H. F. Jefferson, of Rugby.** (1 *Fig.*) February 23, 1945.—This invention is an electrically-controlled soot blower arranged so that the nozzle is withdrawn into a pocket in the boiler wall, except when actually being used for blowing, to avoid the deteriorating influence of the heat on the material of the nozzle. In the accompanying sectional elevation of part of a soot blower, A represents the spindle of a blowing nozzle (not shown), the outer end portion of the spindle being provided with a feather seat in which slides the key B of a gear wheel C. The spindle is rotated by an electric motor (not shown) suitably geared to the wheel C. The end of the spindle A is connected by a thrust bearing D to the piston rod E of a piston F operating in a cylinder G. The supply of operating fluid to the cylinder G is controlled by a double piston valve H, which is biased to the position shown by means of a spring J. In this position the operating fluid enters the valve casing through the port K and passes to the interior of cylinder G through the port Q, thus holding the nozzle A in its withdrawn position. The movable core of solenoid L is connected to the stem of valve H through a bell-crank lever M, and when the

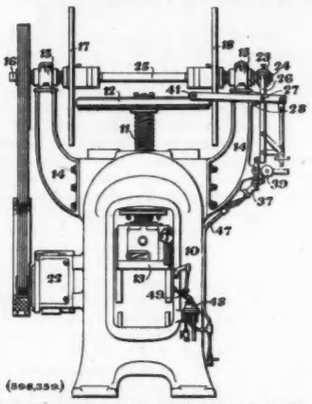


(596,239)

solenoid is energised, the lever forces the stem against its biasing spring until the valve H admits operating fluid to the right-hand end of cylinder G through the port R, the other end of the cylinder being then connected to exhaust. This causes the nozzle to move axially into its working position. Such movement of the nozzle is permitted by reason of the longitudinally sliding engagement of the spindle A with the key B, and when the nozzle is thus projected into the blowing position, a cam N on the spindle A is in a position to co-operate, during rotation, with the roller P of a plunger so as to actuate an operating lever S for pilot-valve mechanism indicated at T, which admits blowing fluid to the interior of the nozzle (not shown) at the desired periods. The energisation of the solenoid L is effected when the electric motor which drives the gear wheel C is connected to the supply, the solenoid being connected across two of the motor terminals so that when the motor is first energised the solenoid will move the valve H against its spring J and while the motor is accelerating, the piston F will force the nozzle to the "in" position. A control switch X is operated by the pilot-valve operating lever S so that reversal of the electric motor is effected immediately the pilot valve closes under the influence of the cam N, and there is no idle time in the blowing zone. (*Accepted December* 31, 1947.)

### MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT.

**598,359. Screw-Operated Press. Hordern, Mason and Edwards, Limited, W. G. Edwards, R. F. Deykin and G. S. Wilson, all of Birmingham.** (2 *Figs.*) December 22, 1944.—This invention is a screw-operated press with a friction drive, the engagement of the friction drive being power operated to save the operator from fatigue. The press consists of a frame 10 in which is a vertical ram 13 operated by a screw 11 rotating in a nut carried in the frame. The sides of the frame are provided with two brackets 14 which carry bearings 15 for a horizontal shaft 16 above the screw 11. The upper end of the screw carries a driving friction-lined wheel 12, and the shaft 16 is provided with a sliding unit, generally indicated at 25, and including a pair of discs 17, 18, the planes of which are vertical. These discs are arranged to engage diametrically opposite points on the periphery of the friction-lined wheel 12 on the screw, one at a time. The unit 25 incorporating the discs can slide on the shaft 16 and is in driving engagement with it. The shaft is power driven by a motor 22 on the side of the frame. The end of the sliding unit 25 beyond the bearing 15 is fitted with a collar 23 which does not rotate but which is prevented from end movement in relation to the sliding unit,

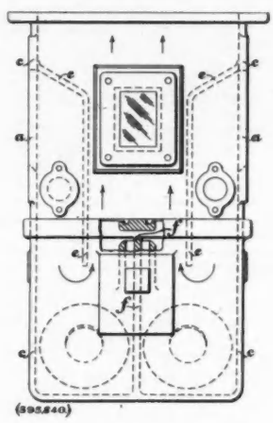


(598,359)

This collar is provided at opposite sides with U-shaped projections 24 which are engaged by the upper ends of a pair of side by side levers 26 pivoted at 27 to a lug 28 on the frame, so that the sliding unit 25 incorporating the discs can be moved endways. The levers 26 are actuated, through a further series of levers, by the piston of an air cylinder 37. A counterweight 39 tends to move the levers in the opposite direction to that in which they are moved by the air cylinder. A braking bar 41, operated from the lever system, is pressed on the disc 12 to bring it to rest at the end of the stroke of the press. A pipe connection 47 connects the air cylinder 37 to a control valve 48, which, in one position, permits compressed air to pass to the cylinder and, in the other position, cuts off the supply of air and opens the pipe leading from the cylinder to exhaust. The control valve is operated by a rocking lever 49, and it may be operated by hand or by the ram 13 of the press. When the air cylinder is automatically connected to exhaust at the end of a down-stroke, the sliding member 25 which includes the two friction discs 17, 18 moves into the reverse position by the gravity loading produced by the counterweight 39 and the weight of the bar 41, so that the motion of the screw reverses and the ram begins to move upward. (*Accepted February* 17, 1948.)

### MISCELLANEOUS.

**595,840. Gas Manufacture. Drakes, Limited, of Halifax, and M. Thompson, of Illingworth, near Halifax.** (4 *Figs.*) August 28, 1944.—The invention is a gas-collecting box which will collect gas from a number of vertical retorts and will permit one or more of a group of retorts to be shut off, when desired, providing and maintaining an effective hydraulic seal on all the retorts it serves. The gas-outlet pipes from a pair of retorts lead at the points *a*, *a* into a collecting box *c* mounted beneath and forming a closure to the lower end of an ascension pipe down which sprays of liquor are projected by means not shown. The ascension pipe as usual, leads into a gas main. Opposite the point of connection of each gas-outlet pipe *a* to the collecting box there is a baffle *e* extending inward and downward from the wall of the box. These baffles *e* run from front to back of the box and extend down to a certain level above the bottom of the box. Projecting upward from the centre of the bottom of the box there is a vertical baffle *f*, which also extends from front to back of the box and terminates at a point above the level of the lower ends of the baffles *e*. Gas entering the box from a retort thus passes downward below the baffle *e*, to rise up into the ascension pipe between the baffle *e* and the central baffle *f*, the course of the gas being indicated by the arrows. The lower part of the collecting box *c* forms a sump for liquor, and in each half



(595,840)

of the sump there is an outlet to a valve-controlled pipe leading to a junction box forming part of a liquor main. A receiver in the main maintains the liquor always at a determined height in each half of the collecting box when the valve controlling that half is open. Extending from end to end of the collecting box at right angles to the baffles *e* and *f* is another baffle which extends below the level of the liquor in the box and in front of this baffle the wall of the box is sloped upward. At a point near the level of the top of the central baffle an overflow pipe is fitted which is connected to the liquor main. When it is desired to shut off a retort, the closing of the appropriate liquor-outlet valve causes the liquor descending the ascension pipe to rise up in that half of the box until it spills over the central baffle *f* and finds its way out through the outlet from the other half of the box. If both retorts served by a box are shut off, the liquor rises in both halves of the box until it reaches the level of the top of the overflow pipe. Thus, a hydraulic seal is at all times maintained in the collecting box and the liquor cannot at any time rise above a determined height in the box. The entrance to the overflow pipe is located below the level of the connections to the box of the gas-outlet pipes from the retorts, so that it is impossible for liquor to find its way into the retorts. (*Sealed.*)

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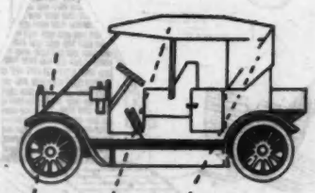

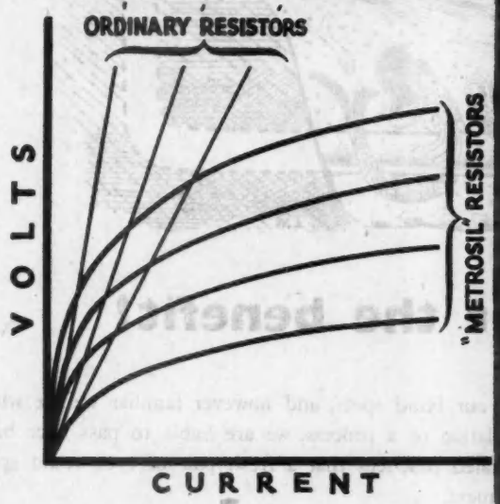


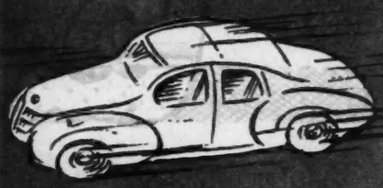

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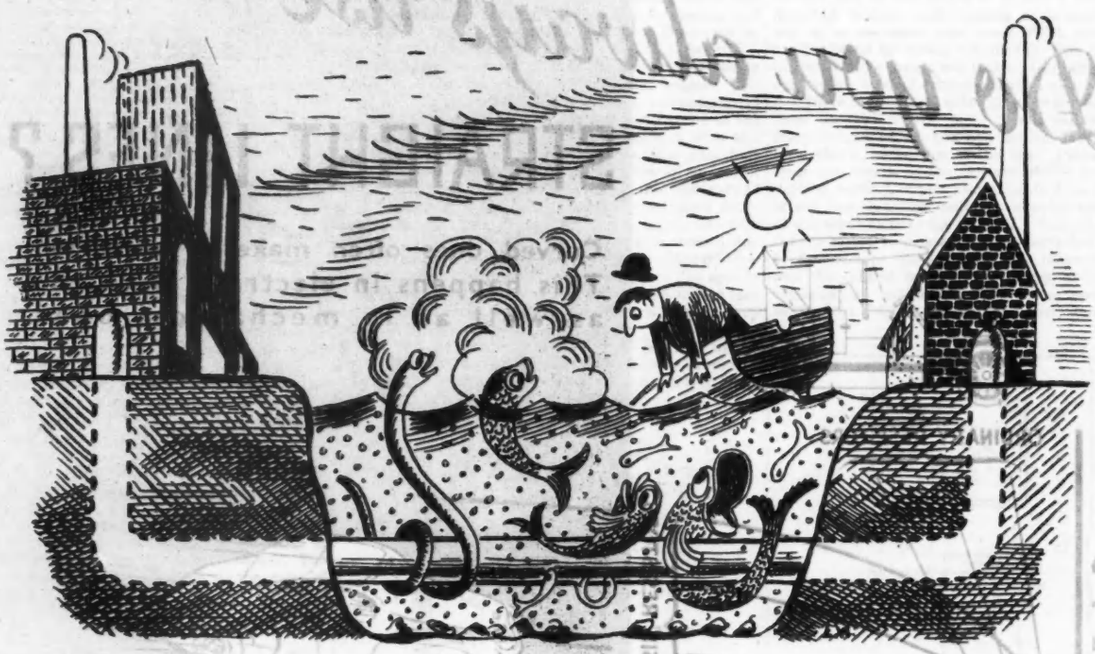

# but only the fish got the benefit!

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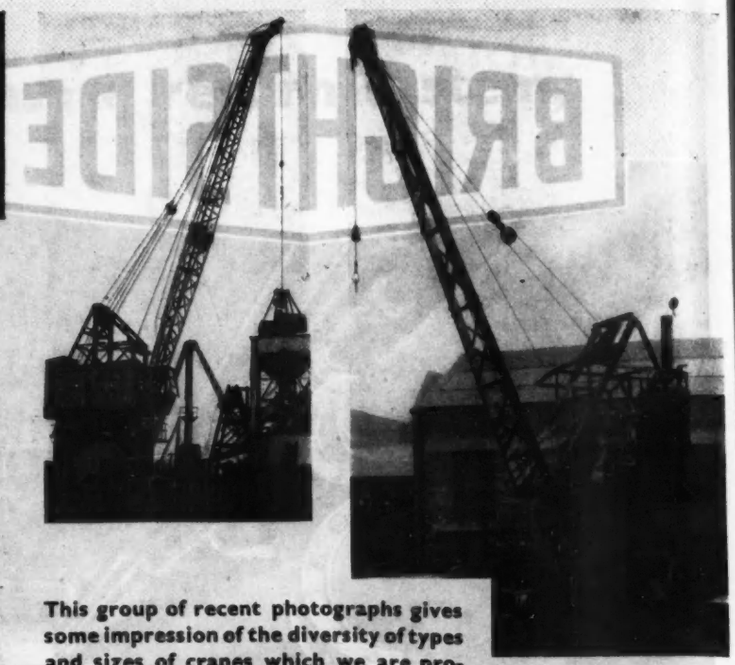

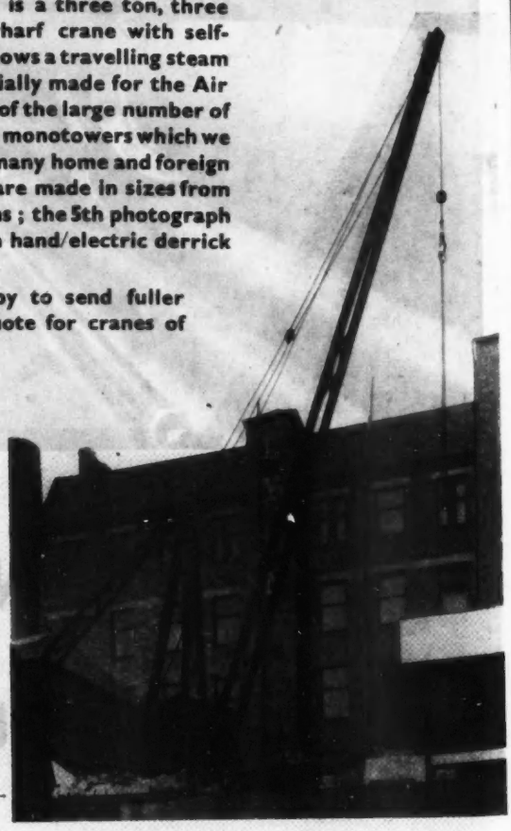

This group of recent photographs gives some impression of the diversity of types and sizes of cranes which we are producing. Picture 1 shows a one ton hand portable crane, 2 is a three ton, three motor electric wharf crane with self-dumping grab, 3 shows a travelling steam gantry crane specially made for the Air Ministry, 4 is one of the large number of electric travelling monotowers which we have supplied to many home and foreign shipyards; these are made in sizes from five to twenty tons; the 5th photograph shows a three ton hand/electric derrick crane.

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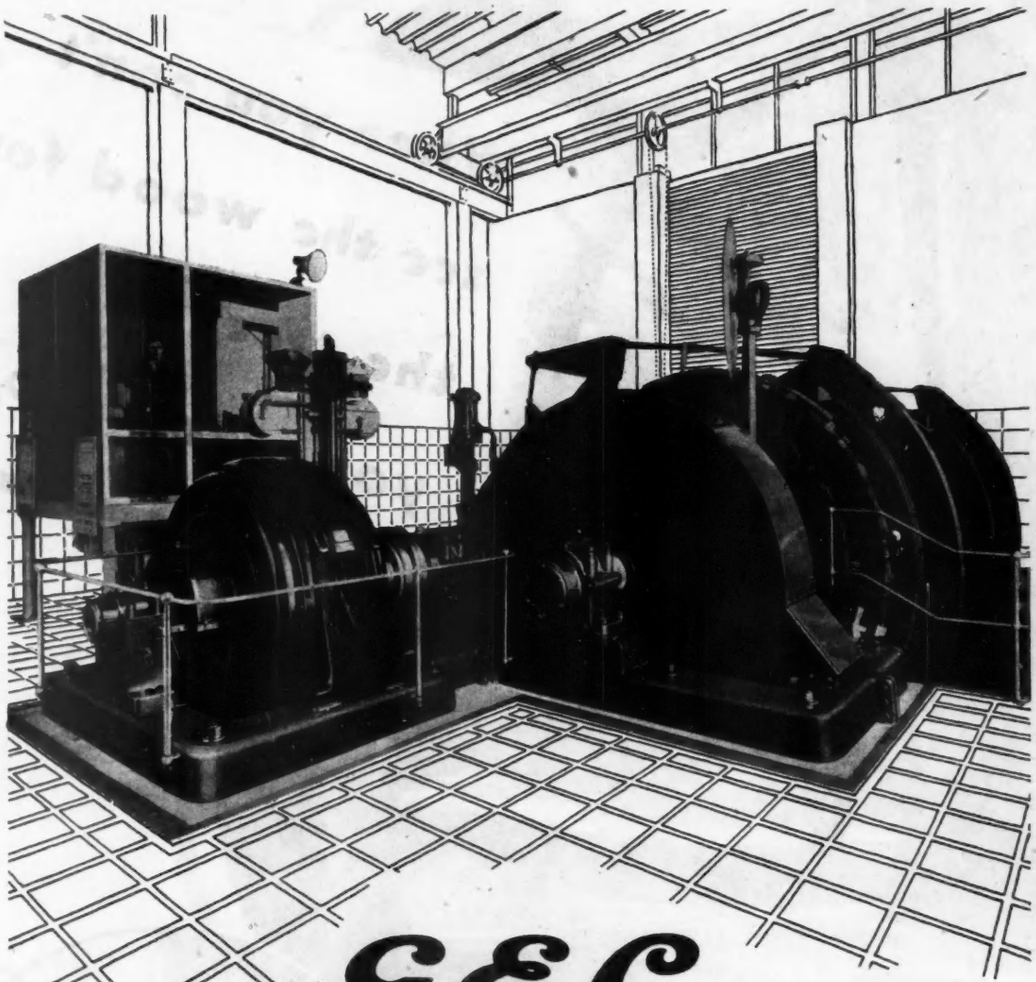

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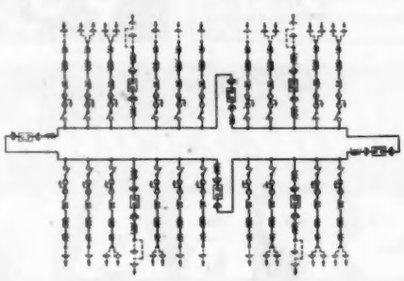

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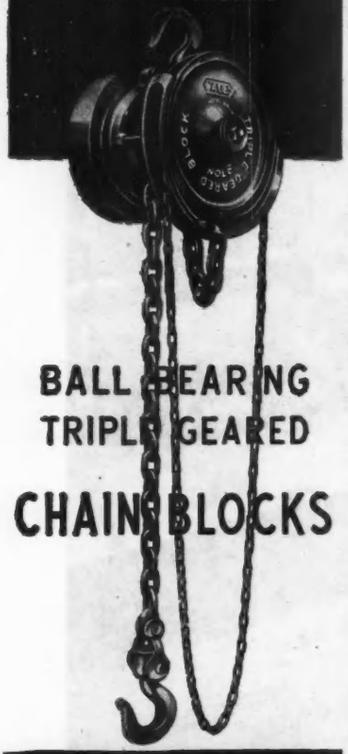

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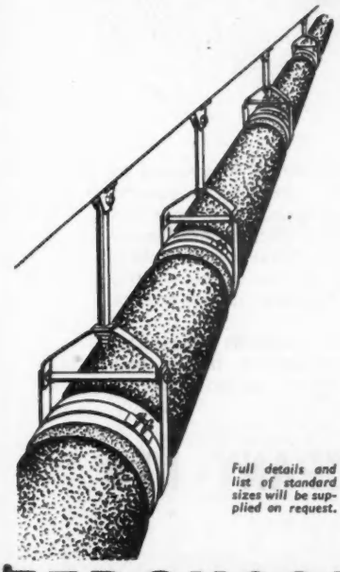

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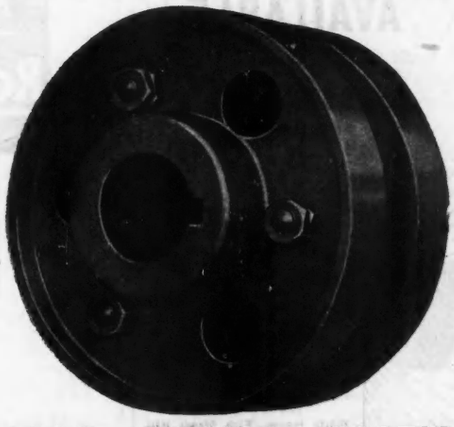

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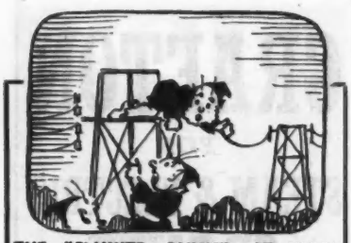

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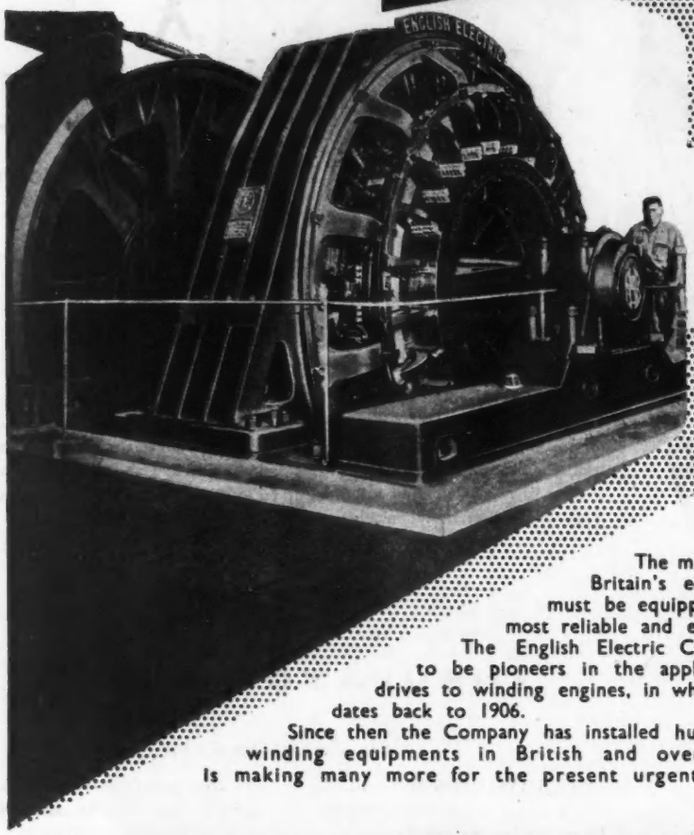

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# The Performance of this CROSSLEY ENGINE is typical of thousands of other CROSSLEY ENGINES the world over

A·W·TINDALL LTD

BARRINGTON MILLS · HOLBEACH

Messrs. Crossley Brothers Ltd.,
Openshaw,
MANCHESTER.11.

September 29th 1947

Dear Sirs,

O.126 Type Engine No. 111207

Your inspector is correct in reporting the excellent service this engine has given. Since it was installed in 1931 it has caused us very few involuntary stops and those of very short duration.

The Flour Mill driven by this engine runs a three shift system of 128 hours continuous running. Of the 24 hours eight is 90% to 100% load, eight 80% and eight 60% load. The valves are ground every 3 or 4 weeks, but we have run for 6 weeks without re-grinding. We have an engineer in charge of the engine on day work, but for the remaining time the shift miller keeps an eye on it and fills up the lubricators.

We have, during the war, run for long periods of 132 hours per week, and several spells of 3 weeks without a stop; the longest run was 4 weeks continuous.

In 1944 we ran 7,600 hours, an average of 146 hours per week, the time lost was for necessary stops for mill cleaning, fumigation and holidays.

Yours faithfully,
per pro A.W. TINDALL LTD.,
J.W. Bennett.
Director.

"We have been working this old engine for fully 30 years and only stopped last Thursday (October 16th, 1947).

I am writing to say it was a wonderful machine, and it no doubt gives you pleasure to know it has lasted and worked so long and well."

Extract from a further letter recently received is shown alongside – it refers to engine N°2965 sold to the original users in 1881.

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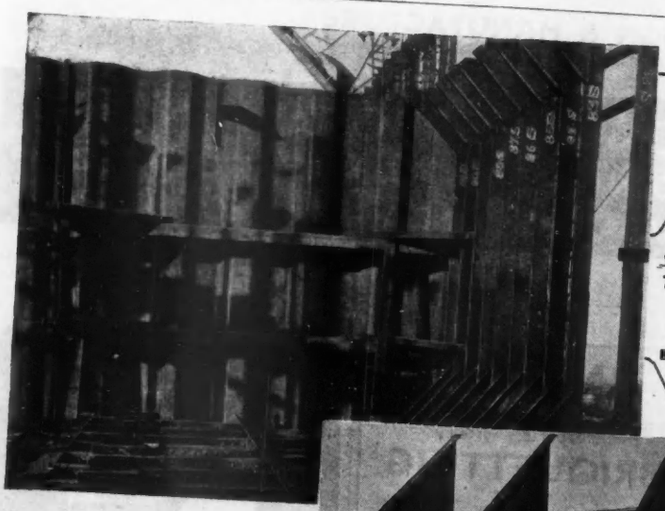

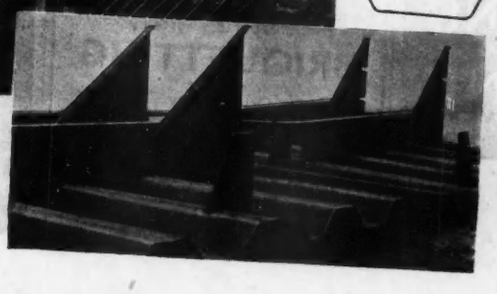

Above:
TRANSVERSE BULKHEAD IN POSITION
At Right:
BULKHEAD WITH GIRDERS AND WEBS ATTACHED READY FOR ERECTION

# PRESSED STEEL TROUGHING FOR *Modern* SHIPS' BULKHEADS

Troughing supplied for bulkheads of M. V. ROVUMA built by Bertram & Sons, Ltd., Sunderland

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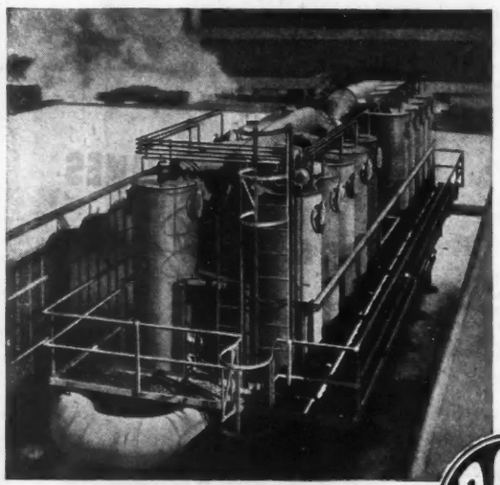

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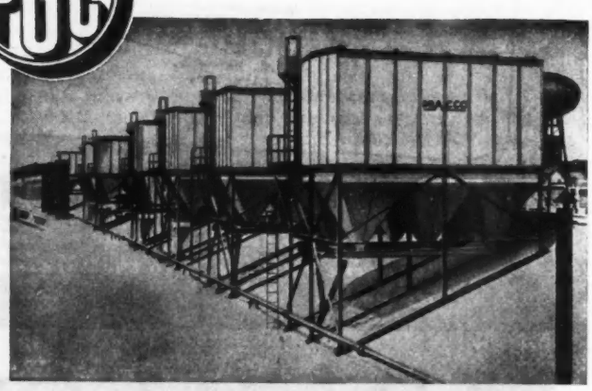

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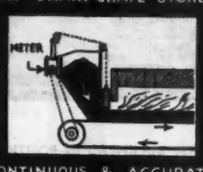


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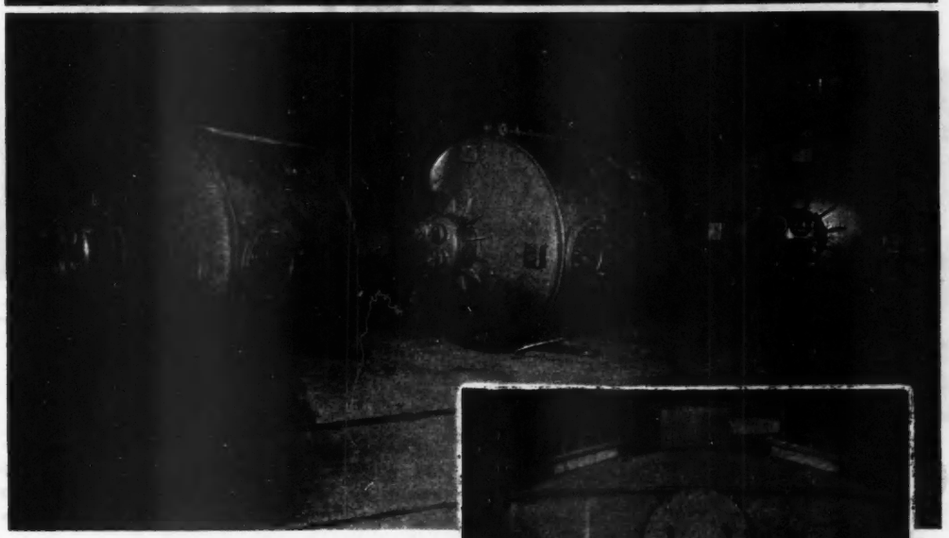

*The upper illustration shows a typical WIDNES job—fabricated mild steel viscose kettles 7 ft. 1 in. diameter by 7 ft. deep on the straight, part of an order for 25, fabricated in accordance with B.S.S. 467.*

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*The inset illustration shows an acetone plant absorber fabricated from ¾ in. plate; overall diameter 9 ft. 6 ins., weighing 4½ tons.*

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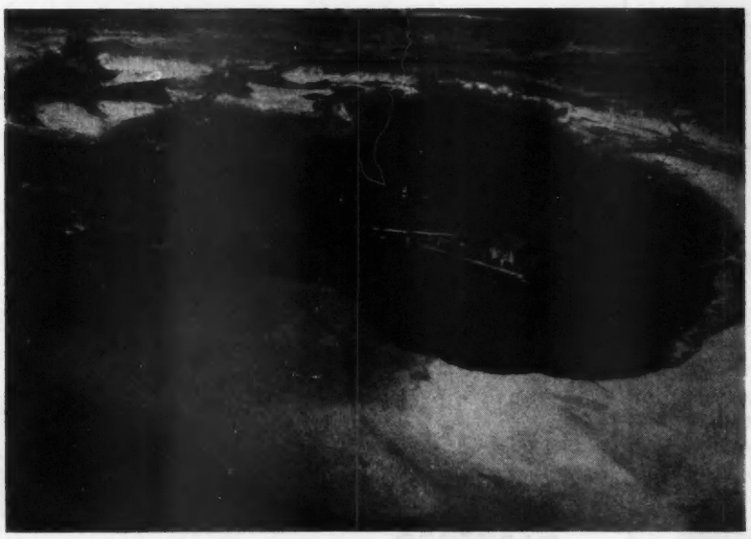

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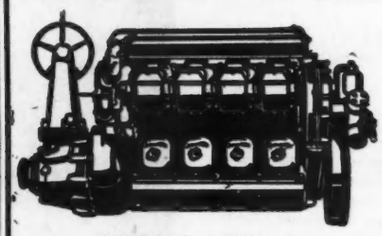

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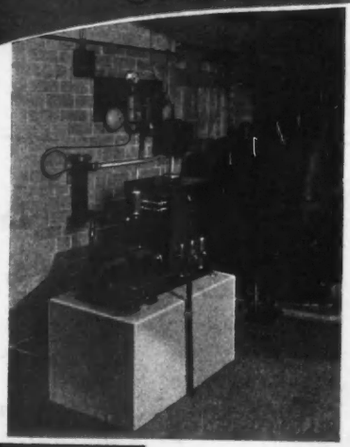
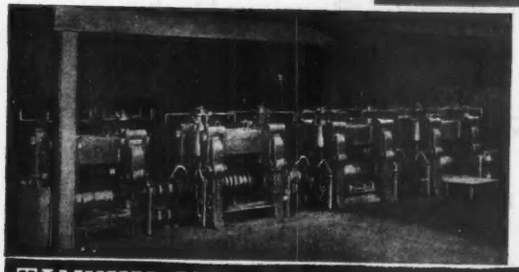


*Unretouched Photograph of a Whitemetal Bearing after 12 months' continuous operation on a Robertson Mill equipped with Tanway Patent Lubrication as shown below.*



*(Above) The Tanway Unit*

Let us show you how to Increase Production and Reduce Rolling Costs. Write to-day for Mill Booklets.

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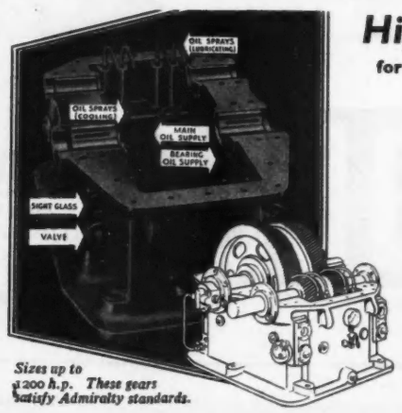


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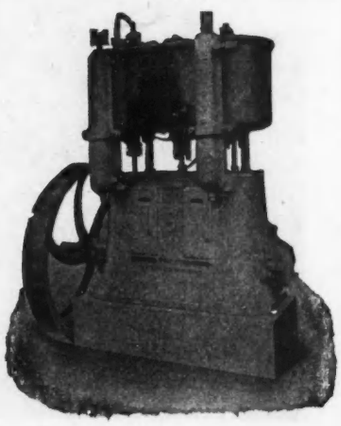

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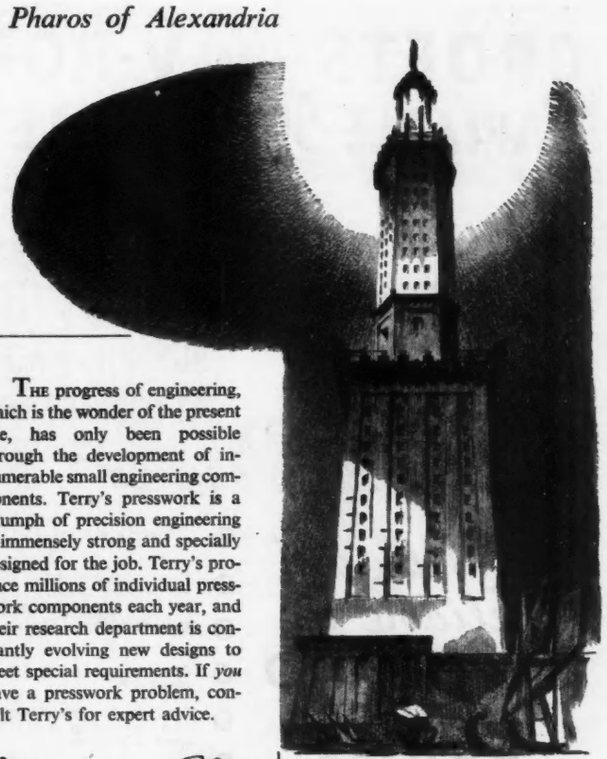

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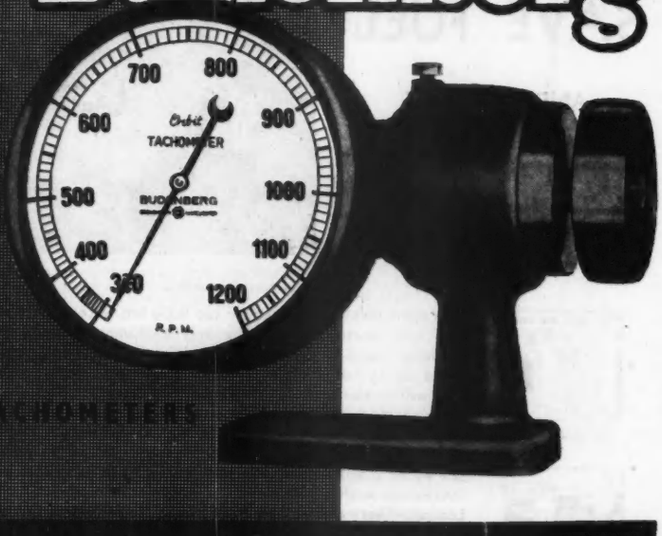


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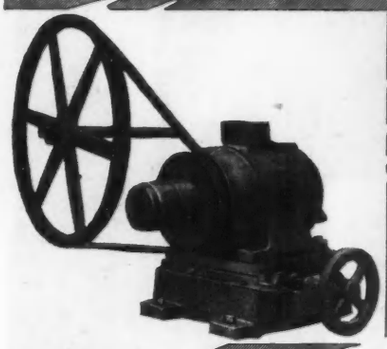

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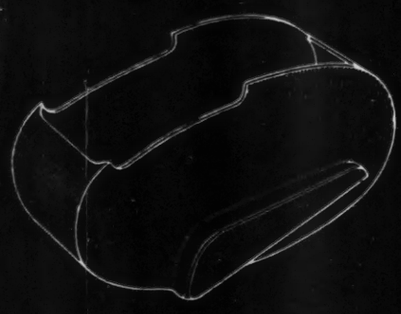

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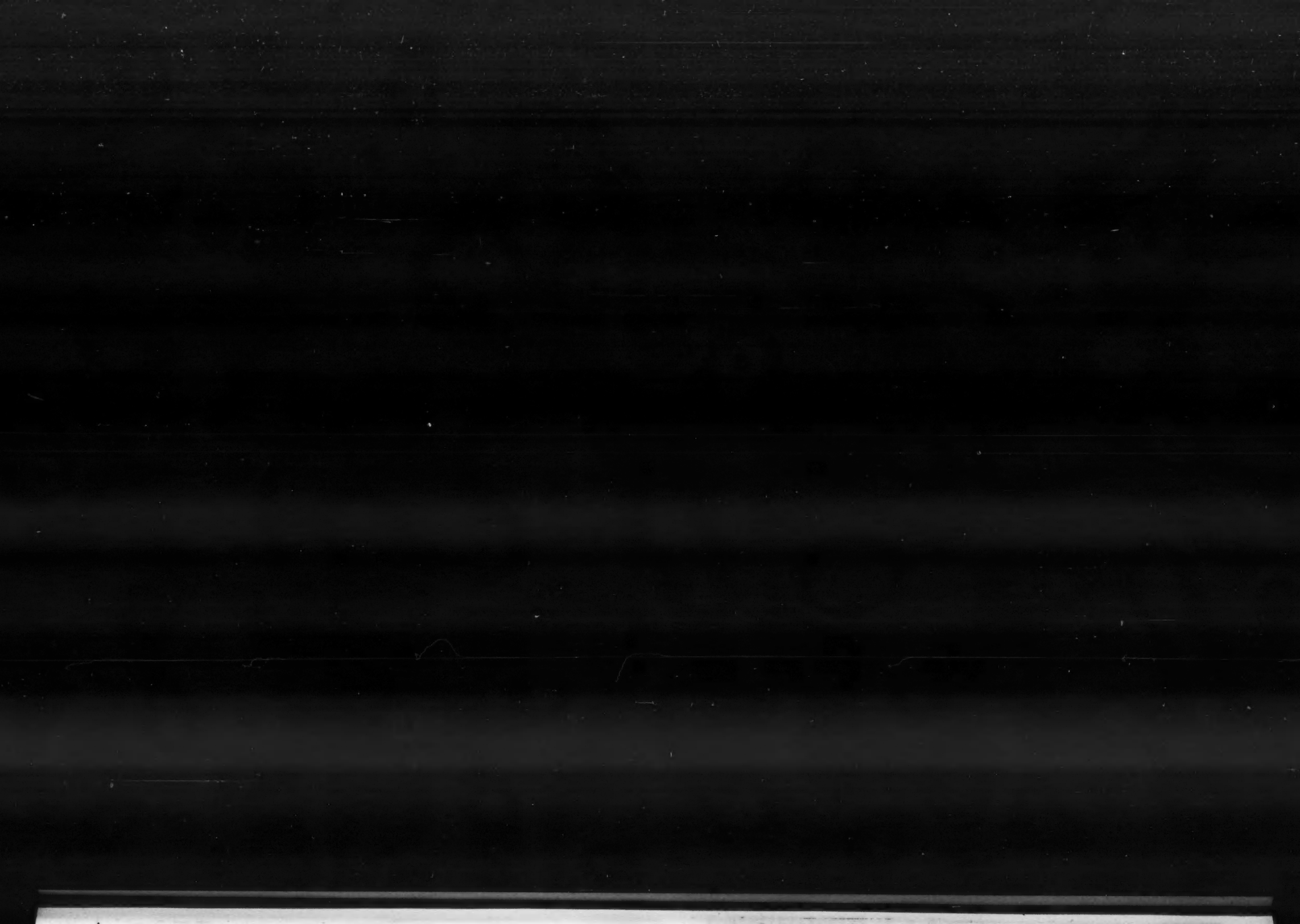

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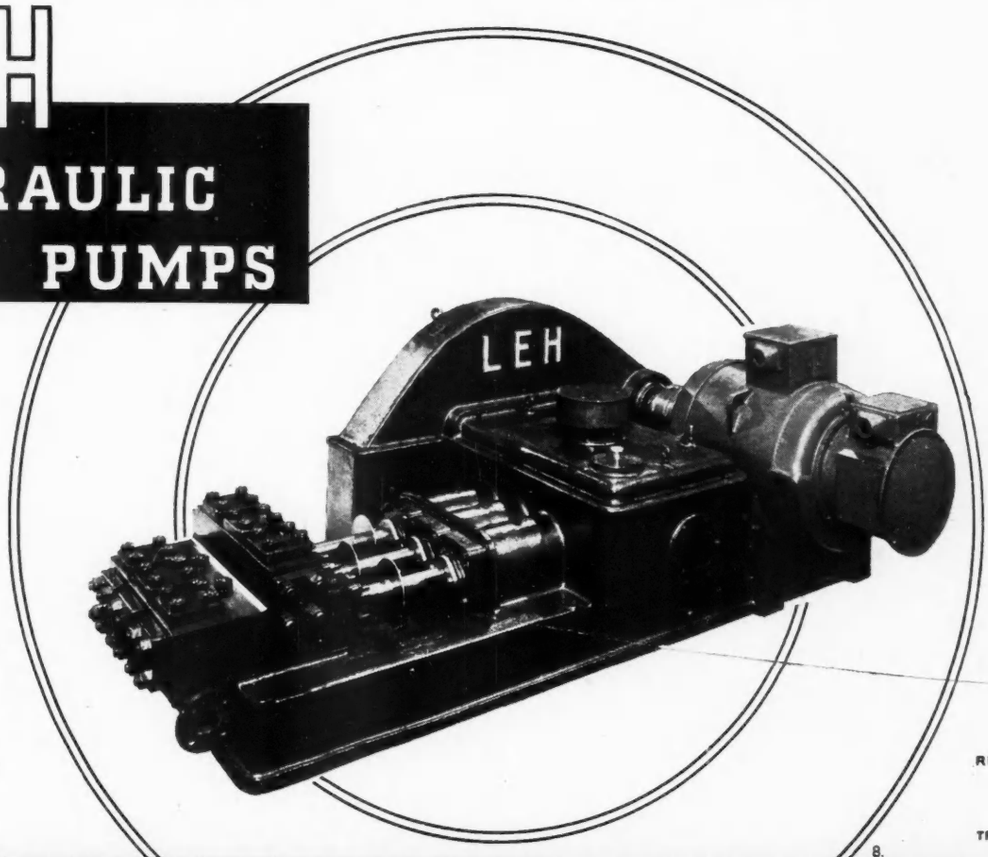
750 to 4500 lbs. per sq. in.

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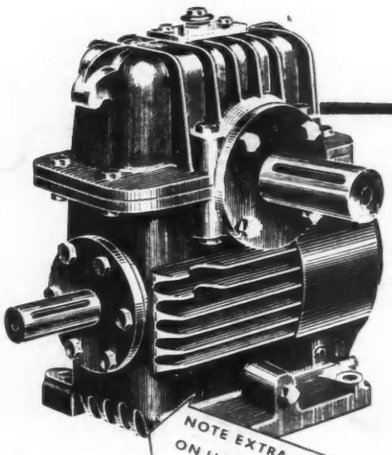


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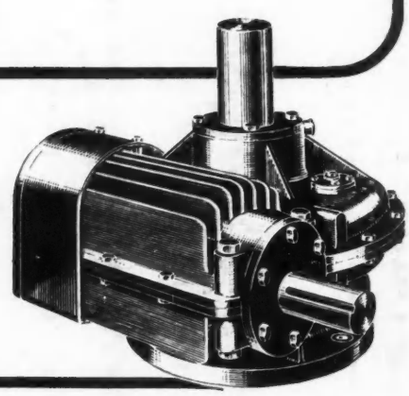

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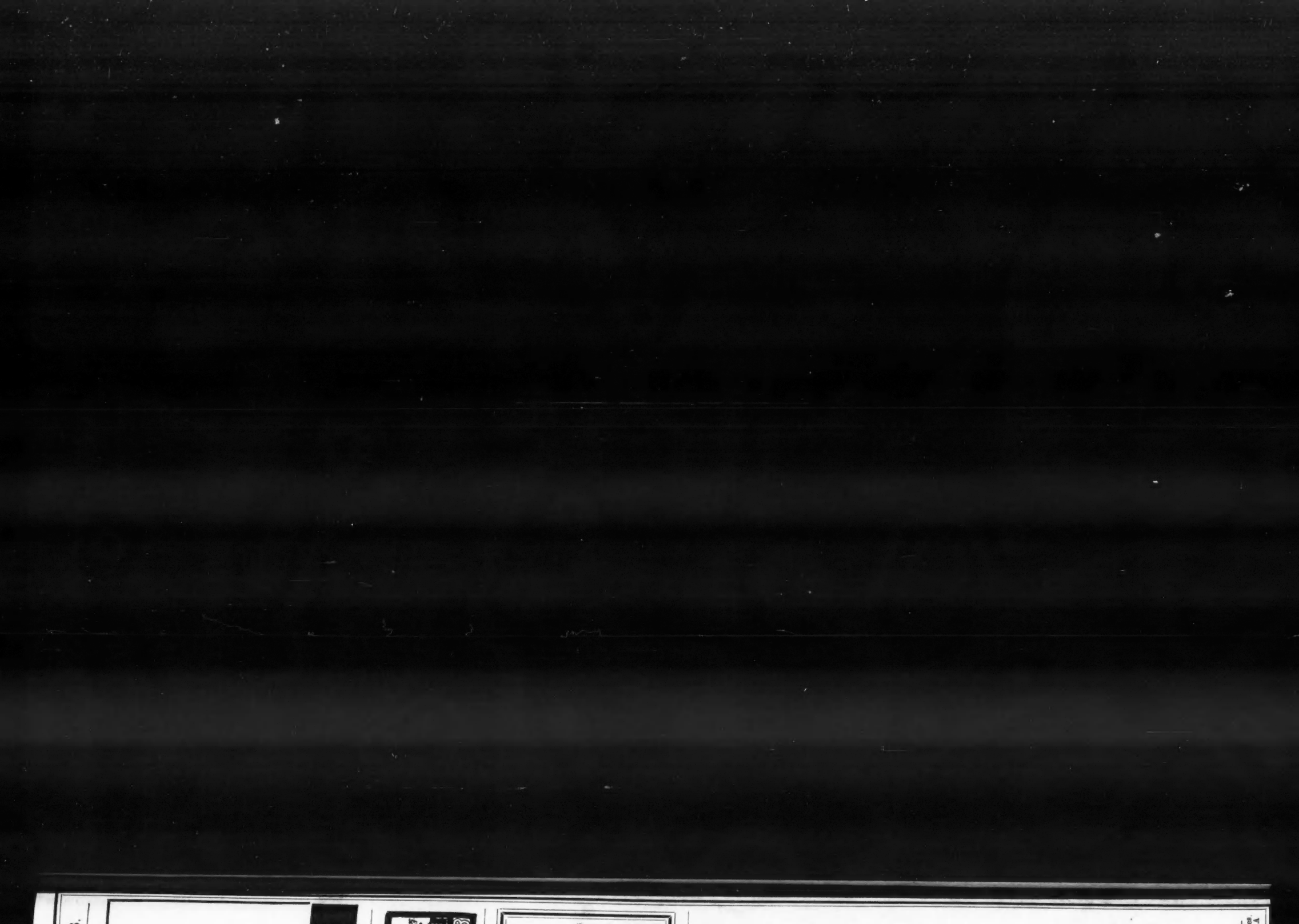
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